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OF
CIVIL ENGINEERS



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6 Beacon Street, Boston

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

FRIDAY, APRIL 21, 1916,

at 8 o'clock P.M., in the Assembly Room of the Engineers' Club, Commonwealth Avenue, corner of Arlington Street, Boston.

The Board of Government will submit a report, prepared by a committee of its members, in relation to Permanent Bench Marks about Boston and Vicinity, and will recommend that the suggestions made in the report be adopted by the Society. The report is printed in this number of the JOURNAL.

Dr. Alexander C. Humphreys, president of the Stevens Institute of Technology and past president of the American Society of Mechanical Engineers, will read a paper entitled, "Reform and Regulation." The paper will have to do with reform in the regulation of public-service utilities.

The Boston Section of the American Institute of Electrical Engineers and the local members of the American Society of Mechanical Engineers have been invited to join in the meeting.

S. E. TINKHAM, *Secretary*.

PAPERS IN THIS NUMBER.

Address at the Annual Meeting, Charles R. Gow.

"Spillways of the Panama Canal," Edward C. Sherman.

"Latest Method of Sewage Disposal," Edward Bartow.

"Service for the Society," Edmund M. Blake.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Power Estimates."	D. M. Wood.	March.	May 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

REPORT OF COMMITTEE ON PERMANENT BENCH MARKS.

LAWRENCE, MASS., February 24, 1916.

TO THE BOARD OF GOVERNMENT,

BOSTON SOCIETY OF CIVIL ENGINEERS, BOSTON, MASS.

CHAS. R. GOW, *President*.

The Committee appointed by the President of the Boston Society of Civil Engineers in relation to Permanent Bench Marks about Boston and vicinity herewith present the following report.

The subject was brought to the attention of the Society through a letter signed by geologists connected with Tufts, Harvard and Technology, dated May 24, 1915, asking for coöperation of the Boston Society of Civil Engineers in relation to establishing permanent bench marks and tide gage in Boston and vicinity. The object was to make a more definite study of the harbor and coast and to determine the effect of the changes which follow such progress with the development of a great city, such as dredging channels, filling flats, building masonry walls, docks, etc.

Investigation in the past by Mr. John R. Freeman, civil engineer, has shown by his report on the Charles River Dam, dated 1903, that a gradual subsidence of the coast about Boston is in progress at the rate of about a foot in one hundred years, and, although other authorities have differed somewhat regarding his opinion, it is considered of great importance that more definite information should be obtained bearing on this subject.

The various correspondence relating to the subject is attached and made a part of this report, and is included in the following list with dates:

May 24, 1915, Professors of Geology to S. E. Tinkham.

June 7, 1915, Prof. Alfred C. Lane to S. E. Tinkham.

*July 1, 1915, J. R. Freeman to R. A. Hale.

December 28, 1915, R. A. Hale to Port Directors, J. L. Howard.

December 29, 1915, R. A. Hale to U. S. Coast and Geodetic Survey.

*December 30, 1915, R. E. Barrett (Port Directors) to Boston Society of Civil Engineers.

January 3, 1916, R. A. Hale to Robert E. Barrett (Port Directors).

*January 10, 1916, U. S. Coast and Geodetic Survey to R. A. Hale.

January 14, 1916, R. A. Hale to U. S. Coast and Geodetic Survey (Faris).

The committee had interviews with various public boards, and found a great willingness to coöperate with them in every possible way. It was apparent, however, that with the large field for investigation it would hardly be possible for one board to carry out the general plan, but that a coöperation must be had with other boards. Your committee wrote to the U. S. Coast and Geodetic Survey for information and suggestions, and received a most courteous reply offering assistance by having a precise leveling party run lines of levels connecting various benches when a comprehensive plan was developed.

The Port Directors have stated that they would set a long rod in the solid ledge during the process of construction of the dry-dock which would be extended to the top of the wall where it would be accessible. A self-recording tide gage is now being established in South Boston, which will be carefully observed.

The Metropolitan Water Board has accurate benches established along the lines of its conduits, which would eventually be connected as part of a uniform system, and a coöperation is assured on their part, as far as practicable.

The City of Boston would be interested through its Highway Departments, and would doubtless coöperate through the engineers of the departments.

The various suggestions are made, as will be seen in the correspondence attached and in which further details are discussed. Your committee would make the following suggestions as a basis of organization: That a committee should be created, consisting of a representative of the Port Directors, a representative of the Metropolitan Water and Sewerage Board, a representative of the City of Boston, a representative of the Boston Society of Civil Engineers, and a representative of the geologists in the vicinity of Boston. This committee could agree on a definite plan of operation, confer with the U. S. Coast and Geodetic Survey, who have offered their services, and whatever is carried out should be a part of a well-defined plan embracing a system of permanent benches and tide gages that would give more definite information than is at present attainable. It doubtless would entail considerable expense to carry out a complete scheme in detail at once, but if a general scheme could be definitely outlined by such a committee, portions of it could be accomplished as opportunity offered and made a part of a final plan with the coöperation of all boards.

Respectfully submitted,

RICHARD A. HALE.

FRANK O. WHITNEY.

PROVIDENCE, R. I., July 1, 1915.

RICHARD A. HALE, CIVIL ENGINEER,
Care of THE ESSEX COMPANY,
LAWRENCE, MASS.

Dear Mr. Hale:

BOSTON BENCH MARKS.

I am much interested in your letter of June 30 and in the recommendations of the Committee on Bench Marks, composed of Shimer, Lingren, Crosby, Lahee and Warren, dated May 24, 1915, at Tufts College and addressed to S. E. Tinkham, Secretary.

My personal opinion is that this matter of bench marks is a very important one and should receive attention.

I believe the work could probably best be carried on by the committee seeking to meet with representatives of the Boston Board of Public Works and of the Metropolitan Water and Sewerage Board, possibly also the Metropolitan Park Commission and the Port Directors, in order to have these, the principal boards of public works bordering on the harbor, coöperate in the precise leveling and in the independent checking and in order that each should in the future recognize a sense of proprietary interest and responsibility in this matter of standard bench marks.

As to the bench marks themselves, my own idea is that there should be more than the three recommended by Professor Woodbridge. I would want more time than I have this morning before making any recommendation in detail as to just where the different bench marks should be located, but in a general way my first thought would be that this location should be somewhat as follows:

No. 1. As near as practicable on solid ledge within public property and easy of access to any engineer in years to come, a reference bench for the tide gages at the Boston Navy Yard and as close as practicable thereto, so as to encourage frequent comparison.

No. 2. A plate could be cut into the side of the Bunker Hill Monument at a point convenient for transfer into the central shaft, with a secondary bench in one or more of the topmost window sills for trigonometric leveling.

No. 3. On the interior of the shaft structure of the East Boston Tunnel at Atlantic Avenue, at a point that can be reached conveniently for precise vertical measurement to a reference point at the bottom of the tunnel and another to the outside of the building.

No. 4. On the Commonwealth Pier at South Boston. This preferably to have its stability assured by a wash boring in a four-inch pipe down to bed-rock, the four-inch pipe being sealed into bed-rock and the hole then continued, say, three inches in diameter for, say, ten feet into the rock, with a steel rod with screw couplings and a jagged end bedded in cement into the ledge by first blowing out the hole, preferably with compressed air, and then filling it with soft cement grout, into which the jagged end of the rod should be forced, thereby making sure of the grip between the rod and the ledge. The

space between the steel rod and the casting pipe should then be filled with coal tar tempered with lime.

If a bar of Invar steel nickel alloy could be procured, it might be made a little smaller, but the cost of this nickel alloy should not be beyond the means of the Commonwealth, and of course the top of the rod would be given appropriate finish and treatment for its preservation. This would naturally serve as the standard bench for South Boston levels.

Continuing around the harbor, a precise bench should be established at Cohasset and transfers made with all possible precision to the Minot's Ledge Lighthouse, with a standard bench and connections for a tide gage at the base.

Similarly, both from Point Allerton and from Point Shirley, transfers should be made to Boston Light, with appropriate connections for a tide gage to be maintained now and then for a full year series.

Incidental to this transfer to Boston Light and the checking across, substandard benches should be left with deep foundations and appropriate precautions against settlement and temperature changes in the masonry at both Point Allerton and Point Shirley or Deer Island.

For the interest of the Metropolitan Water and Sewerage Commission, this line of standard benches might very appropriately be transferred inland and standards left on the solid rock and with elaborate covers and housings at various points within the public reservations.

Very truly yours,

(Signed) JOHN R. FREEMAN.

DIRECTORS OF PORT OF BOSTON.

BOSTON, December 30, 1915.

TO THE BOARD OF GOVERNORS,

BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen,—On December 28, 1915, a letter was received from Mr. Richard A. Hale, representing the committee appointed by the Boston Society of Civil Engineers to investigate and report upon the matter of establishing permanent benches in and around Boston. Accompanying the letter was a communication signed by the consulting geologists of Boston, urging the establishment of a tide-gage station and permanent benches, by public authority, set into granite in the vicinity of Boston Harbor.

A few months ago the Directors of the Port of Boston approved of the establishing by their engineering department of a permanent tide-gage station at Commonwealth Pier No. 5, South Boston. A recording tide gage has been constructed and delivered, but has not as yet been installed.

The establishment of this tide-gage station was intended for the public good, and for the purpose of determining the plane of mean low water, and its installation will give to the pilots and others interested in the actual depths of water in the Boston Harbor channels positive information at any hour of the day.

During the past few months steamships of considerable draft have left this port, and on August 15, 1915, the *Canopic*, of the White Star Steamship Company, left Commonwealth Pier No. 5 drawing 34 ft. 6 ins. aft, and as the main ship channel in Boston Harbor has a depth of but 35 ft. at mean low water, it is becoming necessary that pilots and others should have definite information as to the elevation of the tide.

The Directors of the Port of Boston desire to coöperate with the Boston Society of Civil Engineers in the establishment of permanent benches and tide-gage station, as suggested by the consulting geologists of Boston, and will welcome any suggestions in regard to the installation of the tide gage purchased by the Directors a few months ago.

A contract has been awarded for the construction of a dry-dock at South Boston. This structure will be constructed of cyclopean concrete masonry on ledge rock, and undoubtedly an opportunity can be given for the establishing of a permanent bench in connection with the construction of this structure, by imbedding a rod in ledge rock, or by any method acceptable to your committee.

I desire to call to your attention in connection with the above that there has existed for many years several systems of levels in and around the harbor of Boston, separate systems being maintained by the City of Boston, the Commonwealth of Massachusetts and the United States Government, and the desirability of establishing a uniform system of levels, recognizing the fact that an increasing amount of subsurface work is being done by various public authorities.

Very truly yours,

(Signed) ROBERT E. BARRETT,
Acting Chief Engineer.

DEPARTMENT OF COMMERCE.
THE U. S. COAST AND GEODETIC SURVEY,
WASHINGTON.

JANUARY 10, 1916.

Mr. RICHARD A. HALE,

Vice-President, BOSTON SOCIETY CIVIL ENGINEERS,

CARE OF ESSEX COMPANY, LAWRENCE, MASSACHUSETTS:

Sir, — Your letter of December 29, 1915, in regard to the question of determining the elevations of some substantial bench marks in the vicinity of Boston, has been received, together with copies of certain other letters relating to the same subject.

In reply I wish to state that the Coast and Geodetic Survey is very much interested in the question of the stability of our coasts, and, in consequence, at each of our permanent tide-gages we try to establish a number of bench marks which will be as free as practicable from disturbance by the operations of man or by the superficial settling of the ground.

The plan outlined in your letter and in those accompanying it seems to be a rather elaborate one. It is, however, probably a good one to follow.

It is probable that we can coöperate in carrying it out. I would suggest that the local organizations establish the bench marks, and that one of our observers run the line or lines of precise leveling between them. I can give you a definite reply after the parties interested come to a conclusion as to the amount of leveling to be done. We would furnish the instruments and the observer, free of all cost to the local organizations concerned. It is suggested that some decision be reached shortly in regard to the matter, in order that one of our officers, who will be running levels in New England during the coming summer, may make the necessary leveling in Boston on his way to the field, if we can coöperate with you.

The Coast and Geodetic Survey is not carrying on tidal observations in the vicinity of Boston at the present time, although a series of about thirty years' duration was made at the tidal station at the Charlestown Navy Yard. If the gage is now in operation at that place, the observations are probably being made by the naval authorities or by the officers of the army engineer corps. It is our intention to resume our automatic tide-gage in the vicinity of Boston as soon as funds are available for the purpose. At present the appropriation for tidal work makes it impossible to maintain the Charlestown gage.

Many kinds of bench marks are in use, and some are very satisfactory. I would suggest that a report entitled, "Precise Leveling in New York City," by Frederick W. Koop, be consulted before bench marks are arranged for in connection with the work in Boston and vicinity. It is believed that a copy may be obtained from the Chief Engineer, Board of Estimate and Apportionment, New York City, or you may have a copy in your library. There is no doubt but that, for the best results, bench marks should be established on bed-rock.

We are using, for nearly all of our bench marks, a copper disk properly inscribed, set into masonry buildings, solid rock or concrete. One of these disks will be mailed to you under separate cover. We find that if a visitor to a bench mark finds out just what it is from the inscription, he is not likely to disturb it. Formerly many of our marks were lost through the curiosity of visitors who destroyed them in search of possible "buried treasure."

We shall await further communications from you in regard to these matters.

Respectfully yours,

(Signed) R. L. FARIS,
Acting Superintendent.

MINUTES OF MEETINGS.

BOSTON, March 15, 1916. — The sixty-eighth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, Somerset Street, Boston, at 12.15 o'clock P.M., President Charles R. Gow in the chair.

The reading of the record of the last regular meeting was, by vote, dispensed with and it was approved as printed in the March JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership in the grades named, the following candidates:

Members — Thomas Webster Bean, Charles Henry Breen, Ralph Dutton Hood, George Wallace Lewis, Royal Luther, Dean Peabody, Jr., and Ralph Edward Whitney.

Associates — Francis Bernard Farrell and David R. Howard.

Juniors — Ralph Upton Cross and John Mathes Turner.

The Secretary announced the death of Erasmus Darwin Leavitt, an honorary member of the Society, which occurred on March 11, 1916. By vote the President was requested to appoint a committee to prepare a memoir. The President has appointed as the committee, Charles T. Main and Will J. Sando.

The Secretary read the annual report of the Board of Government, and by vote it was accepted and ordered to be printed in the JOURNAL.

The Treasurer read his annual report and the accompanying report of the Auditors, and by vote they were accepted and ordered to be printed in the JOURNAL.

The Secretary read his annual report, and by vote it was accepted and ordered to be printed in the JOURNAL.

The Librarian read the report of the Committee on the Library, and by vote it was accepted and ordered to be printed in the JOURNAL.

Mr. E. M. Blake presented and read the report of the Committee on Social Activities, and by vote it was accepted and ordered to be printed in the JOURNAL.

The recommendations made in the report of the Committee on the Library were, by vote, referred to the Board of Government, with full powers.

On motion of Past-President Stearns, it was voted to refer to the Board of Government, with full powers, the question of appointing the special committees of the Society.

Mr. F. A. Marston offered the following motion: That the Board of Government be requested to appoint a committee of three members to investigate and report at an early date in regard to arranging for a series of lectures on military engineering.

After a discussion, the following substitute motion, offered by Past-President Eddy, was adopted: That the matter of arranging for a series of lectures on military engineering be referred to the incoming Board of Government, with full powers.

The retiring President, Mr. Charles R. Gow, then delivered the annual address, which is published in this issue of the JOURNAL.

The members then adjourned to the auditorium of the Club to partake of the thirty-fourth annual dinner.

During the dinner, in response to the felicitous calls of the President, short speeches in a happy vein were made by Past-Presidents Eddy and Rollins, and by Mr. Charles H. Eglee. There was also singing of Society songs under the leadership of Mr. Olin, with Mr. Blake at the piano.

At the close of the dinner, business was resumed. The Secretary read the report of the tellers of election, Messrs. Frederic A. Caldwell and N. LeRoy Hammond. In accordance with this report, the President announced that the following officers had been elected:

President — Richard A. Hale.

Vice-President (for two years) — Lewis M. Hastings.

Secretary — S. Everett Tinkham.

Treasurer — Frank O. Whitney.

Directors (for two years) — Arthur W. Dean and Sanford E. Thompson.

The President then presented the President-elect, Mr. Richard A. Hale. Mr. Hale in accepting the office expressed his deep appreciation of the honor conferred upon him and thanked the members most sincerely for their confidence. He promised his best efforts for the coming year to advance the interests of the Society and to promote the success of its meetings.

Past-President Frederic P. Stearns, at the request of the President and in the name of the Society, presented the Desmond FitzGerald Medal for the year 1915 to William S. Johnson,

for his paper entitled, "Ground Water Supplies." Mr. Johnson, in accepting the medal, thanked the Society for the honor conferred in the award of the medal to him this year.

At three o'clock the President presented Dr. Charles H. Tyndall, of Mount Vernon, N. Y., who gave a very interesting lecture on "The Wonders of Ether Waves and Radium and Its Mysteries." By means of experimental apparatus he demonstrated the principles of wireless telegraphy, invisible light, inaudible sounds, telepathy, etc. He also illustrated by actual samples of radium many of its mysterious properties and their influence in explaining well-known scientific phenomena.

In the evening the "Smoker" was held in the auditorium, the attendance being 314. Light refreshments were served and an entertainment followed furnished by the White Entertainment Bureau, in which the following talent appeared: Andrew Vissocchi, accordion virtuoso; Charles Bacon Pettes, classic dancer and female impersonator; Herbert A. Clark, humorist; Edwin M. Whitney, king of story-tellers; and Rollo Hudson, accompanist.

S. E. TINKHAM, *Secretary*.

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, MASS., March 1, 1916. — The annual meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening at the Engineers' Club.

Dinner was served in the Assembly Hall at six o'clock, to 28 members and guests. At the close of the dinner, addresses were made by Gardiner T. Swarts, M.D., bacteriologist, Rhode Island State Board of Health; and by the Chairman of the Section, Stephen DeM. Gage.

The business meeting was opened by Chairman Gage at 7.40 o'clock. The minutes of the past three meetings were ordered printed in the JOURNAL without being read.

The annual report of the Executive Committee was read by the Clerk.

Voted to accept the report and place it on file.

Voted that the following recommendation of the Executive

Committee be accepted and the matter referred to the Board of Government by the incoming chairman:

That the Board of Government of the Society be requested to consider and if possible take measures to provide for definite quarters where the meetings of the Sanitary Section may be held.

A verbal report for the Committee on Outfall Sewers was given by G. A. Sampson.

Voted that the report be accepted and the committee continued as requested.

A verbal report for the Committee on Inverted Siphons was presented by Wm. S. Johnson, chairman. The committee asked that the Executive Committee appoint a meeting for the presentation of a progress report and for discussion of the subject.

Voted to accept the report and continue the committee as requested.

The report of the Nominating Committee was read by the chairman, Almon L. Fales.

Voted to accept the report, and that Mr. Carpenter be instructed to cast one ballot for the list of officers as suggested by the Nominating Committee.

The ballot having been cast by Mr. Carpenter, the following list of officers were declared elected for the ensuing year:

Chairman — Prof. Frederic Bonnet, Jr.

Vice-Chairman — Edward Wright, Jr.

Clerk — Frank A. Marston.

Additional members of the Executive Committee:

Stephen DeM. Gage.

Alfred O. Doane.

Roy S. Lanphear.

On motion of Wm. S. Johnson, seconded by E. S. Dorr, voted: That a committee, of size and make-up as they deem proper, be appointed by the Executive Committee to consider and report upon the subject of "Sewer Assessments."

The chairman then introduced the speaker of the evening, Stanley H. Osborn, M.D., State District Health Officer for the Berkshire District, Mass., who related his "Eight Months' Experiences in Servia with the American Sanitary Commission."

The talk was profusely illustrated with lantern slides made from photographs taken by the speaker. His varied experiences under trying circumstances were told in a most entertaining manner.

Voted: That the thanks of the Section be extended to Dr. Osborn for his courtesy in addressing the meeting.

The incoming chairman of the Section, Dr. Frederic Bonnet, Jr., was then introduced and assumed charge.

Meeting adjourned at 9.45 o'clock.

There were 65 present at the meeting.

FRANK A. MARSTON, *Clerk*.

ANNUAL REPORTS.

ANNUAL REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1915-1916.

BOSTON, MASS., March 15, 1916.

To the Members of the Boston Society of Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 15, 1916.

The total membership of the Society a year ago was 928, of whom 832 were members, 58 juniors, 3 honorary members, 24 associates, and 11 were members of the Sanitary Section only.

The total loss in membership during the year has been 51, of whom 23 resigned, 14 forfeited membership on account of non-payment of dues and 14 have died.

There has been added to the Society during the year a total of 122 members of all grades; 119 have been elected and completed their membership; 3 have been reinstated, 3 juniors and 2 members of the Sanitary Section have been transferred to the grade of member. Two members have been elected and accepted honorary membership, and the honorary member elected last year has accepted his election. Eight applicants have been elected but have not completed their membership, and there are 19 applications now before the Board for action.

The present membership of the Society consists of 6 honorary members, 875 members, 83 juniors, 26 associates and 9 members of the Sanitary Section only, making a total membership of 999, a net gain during the year of 71 members.

The Board of Government by unanimous vote has elected as honorary members, Past President Desmond FitzGerald and Past President Frederic Pike Stearns.

The loss by death during the year is 14, the largest number in any year of the Society's history. The record is as follows:

Isaac Rich, died March 11, 1915.
 Benjamin G. Fogg, died March 14, 1915.
 Alexis H. French, died May 3, 1915.
 Walter Jenney, died May 3, 1915.
 Edmund K. Turner, died May 6, 1915.
 Theodore L. Keppler, died May 24, 1915.
 Lorenzo G. Moulton, died June 9, 1915.
 Ernest P. Whitten, died June 17, 1915.
 Dexter Brackett, died August 26, 1915.
 J. Herbert Shedd, died November 27, 1915.
 Emory A. Ellsworth, died December 8, 1915.
 Thomas F. Richardson, died December 26, 1915.
 S. Foster Jaques, died January 8, 1916.
 John H. Gerrish, died February 7, 1916.

Under authority of By-Law 8, the Board of Government, for reasons which it deems sufficient, has remitted the dues of twenty-three members of the Society.

Eleven meetings have been held during the year, ten regular and one special. The average attendance at the regular and special meetings was 113, the largest being 260 and the smallest 35.

The following papers and addresses have been given:

March 17, 1915.—Address of Retiring President Eddy. Address by Mr. Frederick H. Newell, "Engineering and Economic Results Obtained by the United States Reclamation Service." (Illustrated.)

March 31, 1915.—Special address by Mr. Edward F. McSweeney, "The Future of the Port of Boston." (Illustrated.)

April 21, 1915.—Mr. J. Albert Holmes, "Construction of the Earth Dam at Somerset, Vermont." (Illustrated.)

May 19, 1915.—Prof. Albert Sauveur, "The Structure of Iron and Steel." (Illustrated.)

June 16, 1915.—Prof. Charles F. Binns, "The Application of Clay Products to Some Engineering Problems." (Illustrated.)

September 15, 1915.—Mr. M. J. Lorente, "Some Special Methods of Reinforced Concrete Designs."

October 20, 1915.—Mr. Wm. S. Johnson, "The Water Supply of Salem, Mass." (Illustrated.)

November 17, 1915.—Mr. Frank C. Shepherd, "The Federal Valuation of the Boston and Maine Railroad."

December 15, 1915.—Mr. A. A. Cohill, "The Construction of the Dorchester Tunnels under Fort Point Channel." (Illustrated by lantern slides and motion pictures.)

January 26, 1916.—Mr. Wm. R. Farrington, "Sand and Oil Roads and Surfaces."

February 26, 1916.—Mr. Edward C. Sherman, "The Spillways of the Panama Canal." (Illustrated.)

The Sanitary Section has held seven meetings with an average attendance of 69. The following papers have been presented at the meetings of the Sanitary Section:

March 3, 1915.—"The Sewage Disposal Works at Fitchburg, Mass.," David A. Hartwell.

November 3, 1915.—Excursion to Albany Street pumping station, Bos-

ton, at 5 o'clock P.M., followed in the evening by a paper, "The South End Sewer System," Edgar S. Dorr.

November 24, 1915. — "Mosquito Extermination Work," Harold I. Eaton.

December 1, 1915. — "Proposed Improvements of the Quequechan River, Fall River, Mass.," Frederic H. Fay.

January 5, 1916. — "Sanitary Work in the United States Army," Maj. James F. Hall, Medical Corps, U. S. A.

January 10, 1916. — "Activated Sludge," Dr. Edward Bartow.

February 2, 1916. — "The Reconstruction of the Cambridge, Ohio, Water Works," W. J. Sherman.

The Joint Engineering Dinner was held at the Boston City Club on Tuesday, February 8, 1916, under the direction of a committee representing this Society, the Boston Section of the American Institute of Electrical Engineers and the local members of the American Society of Mechanical Engineers, the latter organization taking the more active part in the management this year. The attendance was 384. The meeting was addressed by his Excellency Governor McCall, and others, and proved to be one of the most enjoyable of these annual functions.

On April 29, 1915, the students in the civil engineering courses at Harvard Institute of Technology and Tufts were entertained by the Society at Ford Hall; a few students were also present from Worcester Polytechnic Institute and from the Thayer School at Dartmouth. The attendance was about 264.

The Board of Government has adopted the recommendation of the committee appointed to award the Desmond FitzGerald medal and announces that it will be given this year to William S. Johnson for the paper entitled "Ground Water Supplies," which was published in the JOURNAL of the Society for May, 1915.

The work of rearranging and cataloguing the library has been continued during the year. Two new steel stacks and a periodical rack have been added, as well as other furnishings. For this purpose the Board expended \$554.61, which sum has been paid from the special appropriation made from the Permanent Fund in November, 1912. The unexpended balance of this appropriation, amounting to \$58.91, has been returned to the Permanent Fund in accordance with By-Law 9.

Under a provision of the will of our late associate, Edmund K. Turner, the Society has received from the executors of his estate the engineering books in his library, numbering 1,105 bound volumes. While some are duplicates of those already in the library, they make a substantial addition to our library, especially in the line of railroad engineering literature. Mr. Turner made a further bequest of the sum of \$1 000, the income of which is to be used for library purposes. This bequest has been paid over to the Society and, by vote of the Board, it is to be carried on the Treasurer's book as a separate fund, known as the Edmund K. Turner Fund.

A bequest of \$1 000 is made the Society in the will of Past President Alexis H. French, the income of which is to be used for library purposes. This bequest, however, will not be immediately available.

The report of the Editor of the JOURNAL for the calendar year 1915, which is submitted for publication with the reports of the other officers of the Society, shows that a total of 742 pages was printed in the ten issues, with 49 cuts and 5 inserted plates, at a gross cost of \$2 726.11. The net cost, after deducting sums received for advertisements, sales of JOURNAL, etc., was \$1 185.62, or an average of \$118.56 per issue.

This net cost to the Society of the JOURNAL, of a little less than \$1 200 per year, shows that the adoption of an independent publication by the Society has resulted to its financial advantage, as the average cost to the Society of the *Journal of the Association of Engineering Societies* was about \$2 000 per year, or about \$1 850 per year when the net profit derived from the *Bulletin* is considered.

There has been added to the Permanent Fund during the year \$1 613.25. The present value of this fund is now \$37 475.69, and, with the Edmund K. Turner Fund, makes the total invested funds of the Society \$38 475.69, an increase during the year of nearly \$3 900.

From the Treasurer's report it appears that the revenue for the year applicable to current expenses has been \$9 273.33, while the amount expended has been \$8 504.92, leaving an excess of revenue over expenses of \$768.41, which, added to balance at the beginning of the year, makes the total cash on hand in the Current Fund \$1 194.89.

The Committee on Social Activities, under the direction of its efficient chairman, Edmund M. Blake, has continued the excellent work begun last year, and the informal dinners which have been arranged to immediately precede our regular meetings have been heartily appreciated by the members participating. The report of the committee gives the detail of these most enjoyable gatherings:

The Committee on Papers and Program, Lewis E. Moore, chairman, has provide the speakers and papers for the regular meetings, and the Society is under great obligation to the members of this committee for their most satisfactory service during the past year.

While the Committee on Membership, John E. Carty, chairman, have not deemed it best to conduct as vigorous a campaign for new members as last year, the result of their work is seen in the very substantial addition to our membership.

For the Board of Government,

CHAS. R. GOW, *President*.

REPORT OF THE TREASURER.

BOSTON, March 1, 1916.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year 1915-16:

Detailed data are contained in the appended tabular statements. Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; and Table 3, investment of the Permanent Fund.

The revenue applicable to current expenses has been \$9 273.33, about \$1 100 greater than for the preceding year. The current expenses were \$8 504.92. The surplus in the current funds has increased to \$1 194.89.

There has been expended from Furnishings Fund \$554.61, and the balance of \$58.91 has been transferred to the Permanent Fund.

There has been added to the Permanent Fund during the year \$2 893.56, including \$58.91, the unexpended balance of the Furnishings Fund.

A new fund has been created, to be known as the "Edmund K. Turner" Fund, in accordance with a bequest of \$1 000 under the will of our late fellow-member, Edmund K. Turner.

Respectfully submitted,

F. O. WHITNEY, *Treasurer.*

TABLE I. — RECEIPTS AND EXPENDITURES.
CURRENT FUND.

<i>Receipts.</i>	
Balance from March, 1915.....	\$426.48
Members' Dues.....	7 550.83
Advertisements.....	1 580.50
Sales of JOURNALS.....	101.56
Library Fines.....	7.70
Engineers' Joint Dinner.....	8.09
Waste Paper Sold.....	2.59
Interest.....	22.06
	\$9 699.81
<i>Expenditures.</i>	
Journal.....	\$2 721.20
Printing, Postage, Stationery and Library Supplies.....	991.67
Rent (net).....	1 640.00
Light.....	47.12
Salaries (except Editor).....	2 008.00
Reporting.....	46.90
Stereopticon.....	59.02
Books.....	44.13
Binding.....	216.15
Periodicals.....	51.00
Incidentals and Repairs.....	160.87
Insurance.....	35.44
Telephone (net).....	41.16
Sanitary Section Incidentals.....	73.25
Annual Meeting and Dinner.....	80.42
Students' Meeting.....	193.94
Committee on Social Activities.....	94.65
Cash on hand, March 1, 1916.....	1 194.89
	\$9 699.81

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FURNISHINGS FUND.

Cash balance March, 1915.....	\$613.52
Furniture Purchased.....	\$554.61
Transferred to Permanent Fund Income.....	58.91
	<u>\$613.52</u>

PERMANENT FUND.

Receipts.

Cash on hand March, 1915.....	\$227.73
Entrance Fees.....	1 045.00
Contribution.....	100.00
Republican Valley R. R. Bond Sale.....	600.00
Interest (including \$58.91 from Furnishings Fund).....	1 613.25
	<u>\$3 585.98</u>

Paid Out.

Coöperative Bank Dues.....	\$825.00
Superior Water, Light & Power Co. Bond Purchased.....	842.50
Wheeling Light Securities Co. Bond Purchased.....	950.00
Cash on hand, March 1, 1916.....	968.48
	<u>\$3 585.98</u>

E. K. TURNER FUND.

Received from Estate of E. K. Turner	\$1 000.00
--	------------

TABLE 2. — COMPARATIVE BALANCE SHEETS.

	March 19, 1913.	March 18, 1914.	March 17, 1915.	March 1, 1916.
Assets.				
Cash.....	\$353.26	\$119.41	\$1 267.73	\$3 163.37
Bonds and Notes.....	26 615.50	27 605.50	29 191.75	30 366.25
Stock.....		1 950.00	1 950.00	1 950.00
Coöperative Banks.....	5 315.80	3 545.72	3 212.65	4 190.96
Accounts Receivable (Rent).....	145.83	145.83	145.83	
Library.....	7 500.00	7 500.00	7 500.00	7 500.00
Furniture.....	1 175.65	1 325.15	1 950.49	2 405.11
	<u>\$41 106.04</u>	<u>\$42 191.61</u>	<u>\$45 218.45</u>	<u>\$49 575.69</u>
Liabilities.				
Permanent Fund.....	\$29 933.84	\$31 864.29	\$34 582.13	\$37 475.69
Edmund K. Turner Fund Unexpended Appropria- tions.....				1 000.00
	1 051.40	851.46	613.52	
Current Funds.....	1 310.15	535.71	451.31	1 194.89
Accounts Payable.....	135.00	115.00	121.00	
Surplus.....	8 675.65	8 825.15	9 450.49	9 905.11
	<u>\$41 106.04</u>	<u>\$42 191.61</u>	<u>\$45 218.45</u>	<u>\$49 575.69</u>

TABLE 3.—INVESTMENT OF THE PERMANENT FUND, MARCH 1, 1916.

	Par Value.	Actual Cost.	Present Market Value.	Value as Carried on Books.
Bonds.				
American Tel. & Tel. Co. col. tr. 4%, 1929.....	\$3 000.00	\$2 328.75	\$2 760.00	\$2 737.50
Union Elec. Light & Power Co. 5%, 1932.....	2 000.00	2 050.00	2 000.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1939.....	2 000.00	1 995.00	2 000.00	1 995.00
Dayton Gas Co. 5%, 1930.	2 000.00	2 000.00	1 960.00	2 000.00
Milford & Uxbridge St. Ry. 5%, 1918.....	3 000.00	2 942.50	3 000.00	2 942.50
Railway & Light Securities Co. 5%, 1939.....	3 000.00	3 000.00	2 880.00	3 000.00
Superior Light & Power Co. 4%, 1931.....	4 000.00	3 347.50	3 360.00	3 347.50
Wheeling Electric Co. 5%, 1941.....	4 000.00	3 845.00	3 800.00	3 845.00
Economy Light & Power Co. 5%, 1956.....	1 000.00	990.00	950.00	990.00
Tampa Electric Co. 5%, 1933.....	2 000.00	2 000.00	1 980.00	2 000.00
Galveston Houston Elec. Ry. Co. 5%, 1954.....	2 000.00	1 940.00	1 840.00	1 940.00
Northern Texas Elec. Co. 5%, 1940.....	2 000.00	1 932.50	1 800.00	1 932.50
Chicago & Northwestern Ry. 5%, 1987.....	1 000.00	1 102.50	1 160.00	1 102.50
	\$31 000.00	\$29 473.75	\$29 490.00	\$29 882.50
Note.				
Dallas Elec. Co. 5%, 1917.	500.00	483.75	495.00	483.75
Stock.				
15 shares Am. Tel. & Tel. Co.	1 500.00	1 950.00	1 912.50	1 950.00
Total Securities.....	\$33 000.00	\$31 907.50	\$31 897.50	\$32 316.25

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Coöperative Banks.

25 shares Merchants Coöperative Bank, including interest to March	\$1 708.00
25 shares Volunteer Coöperative Bank, including interest to January	1 386.10
25 shares Watertown Coöperative Bank, including interest to December	1 096.86
	\$4 190.96
Total value of Invested Funds	\$36 507.21
Cash on hand	968.48
Total value of Permanent Fund	\$37 475.69
Edmund K. Turner Fund	1 000.00
Total value Permanent Funds	\$38 475.69

REPORT OF THE AUDITING COMMITTEE.

BOSTON, MASS., March 15, 1916.

We hereby certify that we have this day examined the books and records of the Treasurer of the Boston Society of Civil Engineers for the year 1915-16; that all receipts are properly accounted for and that there are proper vouchers for all expenditures.

We have also examined the securities and investments of the Society's funds, have verified and compared the same with the books and found them all accounted for and properly carried.

We have compared the financial statement of the Treasurer with the books and find it to be correct.

EDMUND M. BLAKE,
GEORGE C. WHIPPLE,
Directors.

BOSTON SOCIETY OF CIVIL ENGINEERS.

ANNUAL REPORT OF THE SECRETARY, 1915-16.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS. *Dr.*

For cash received during the year ending March 15, 1916:

From entrance fees, new members and transfers:

86 members and associates.....at \$10 =	\$860.00
32 juniors.....at 5 =	160.00
5 transfers to member.....at 5 =	25.00

Total from entrance fees..... \$1 045.00

From annual dues for 1915-16, including dues of new

members..... \$7 437.83

From back dues..... 52.00

From dues for 1916-17..... 61.00

Total from dues..... 7 550.83

From rents..... 1 000.00

From advertisements..... 1 580.50

From sale of JOURNALS and reprints..... 101.56

From contribution to building fund..... 100.00

Total..... \$11 377.89

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

EDMUND M. BLAKE,

GEORGE C. WHIPPLE,

*Auditing Committee of Directors of the
Boston Society of Civil Engineers.*

ANNUAL REPORT OF LIBRARY COMMITTEE, 1915-16.

BOSTON, MASS., March 15, 1916.

To the Boston Society of Civil Engineers:

The Library Committee submits the following report for the year 1915-16.

Since the last report 922 volumes bound in cloth and 504 bound in paper have been added to the library, making a total of 1 426 accessions.

There are now 8 702 cloth-bound volumes in the library. Those bound in paper now number in the vicinity of 2 500, in spite of the amount of binding done during the year, but this estimate includes a considerable number of duplicates which will be eliminated later from collections of pamphlets donated by members.

During the year 335 books have been loaned to members, and fines to the amount of \$7.70 have been collected.

There has been an increase, both real and apparent, over previous years, in the amount of binding done. Not only have files begun in past years been brought to completion and bound, but the number of periodicals and society publications bound regularly has increased. The *Electric Railway Journal*, the *Concrete-Cement Age*, the *Canadian Engineer* and the *Journal of the Cleveland Engineering Society* have been added to the publications bound regularly, and the binding of still others is under consideration. The Society's file of the Water-Supply Papers of the United States Geological Survey has been brought up to date, and twenty-two volumes of the same bound during the year.

Twelve new engineering books have been purchased for Section 10, and three others, Volumes I and II of "The Principles and Practice of Surveying," by Messrs. Charles B. Breed and George L. Hosmer, and Volume III of "American Sewerage Practice," by Messrs. Leonard Metcalf and Harrison P. Eddy, have been presented to the library by the authors.

The Society is indebted to Mr. William F. Morse for a complete set of the Transactions of the Fifteenth International Congress on Hygiene and Demography, held in Washington in 1912, and to Mr. Fred M. Twombly for ten volumes of the Proceedings of the American Railway Master Mechanics' Association.

The committee also wishes to acknowledge the Society's indebtedness to Mr. Percy M. Blake, who has donated a considerable number of reports to the library, as well as a number of text-books of historical interest.

At the regular meeting of the Society in June, 1915, the committee presented a set of revised rules for the circulation of the books in the library, which rules were adopted at that meeting and printed in the September issue of the JOURNAL. Chief among the changes made were the limiting of the time for keeping out books to two weeks instead of five, and the provision by which "volumes belonging to a set — such as volumes of bound periodicals and of proceedings of transactions of societies — may be taken from the rooms for a limited time only, by special arrangement with the attendant."

Your committee has for some time been considering a more satisfactory way of stamping the books with the Society's name, and has finally purchased a perforating stamp, the mark of which can be eradicated only by removing the page or portion of a page bearing it.

The report of the Board of Government mentions the fact that under the will of our late associate, Edmund K. Turner, the Society has been the recipient of engineering books to the number of 1 105, and of a further bequest of \$1 000, the income of which is to be used for the maintenance of the Society's library. Of the 1 105 books received, only 603 have been placed on the regular shelves and are included in the year's accessions as stated above. The remainder of these volumes consists of reports and bound periodicals, which are duplicates of those already in the library and for which there is not room on the shelves at present. These, if disposed of, would bring only a trifling sum, while it would cost the Society a considerable amount to replace

the volumes of which these are duplicates, if obliged to do so through loss by fire, or any other cause. Some of these, in all probability, could not be replaced at all. Your committee therefore recommends that a suitable and safe place be provided for the storage of these and other duplicate volumes of value.

The question of storage room at Society headquarters also calls for attention. The lack of such storage room, both for office supplies and for material donated to the library, pending examination and the elimination of duplicates, is a serious handicap to the work of the library. At present there is no storage room for such material except on the regular shelves, which makes it impossible to keep the latter in a semblance of order, and necessitates innumerable shiftings and handlings over before the material is finally disposed of.

To the furnishings of the library have been added since the last report a second accession case, a new periodical rack and two new steel stacks, these last being made necessary by the unusual number of accessions during the year.

The work of reclassifying and recataloguing the library is still being carried on, and has progressed considerably in spite of interruptions. Section 4, state reports, and Section 10, engineering text-books, have been entirely reclassified and recatalogued; Section 1, society publications, is nearly completed, and Section 5, United States government reports, is well under way.

The committee recommends that a sum not less than one hundred dollars be appropriated for the purchase of current engineering books during the coming year.

S. E. TINKHAM,
FREDERIC I. WINSLOW,
HENRY F. BRYANT,
Committee on Library.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 1, 1916.

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year, marking the twelfth in the history of the Section, seven meetings were held, the subjects and speakers being as follows:

March 3, 1915. — "The Sewage Disposal Works at Fitchburg, Mass.," David A. Hartwell.

November 3, 1915. — Excursion to Albany Street pumping station, Boston, at 5 o'clock P.M., followed in the evening by a paper, "The South End Sewer System," Edgar S. Dorr.

November 24, 1915. — "Mosquito Extermination Work," Harold I. Eaton.
December 1, 1915. — "Proposed Improvements of the Quequechan River, Fall River, Mass.," Frederic H. Fay.

January 5, 1916. — "Sanitary Work in the United States Army," Maj. James F. Hall, Medical Corps, U. S. A.

January 10, 1916. — "Activated Sludge," Dr. Edward Bartow.

February 2, 1916. — "The Reconstruction of the Cambridge, Ohio, Water Works," W. J. Sherman.

Preliminary arrangements were made for a meeting in June, but as it seemed best to join with the main Society and the New England Water Works

Association in the excursion to Pemberton, the speaker, Prof. C. F. Binns, addressed the regular meeting of the Society, instead of the Section, on "The Application of Clay Products to Some Engineering Problems."

Of the papers presented, two have been published, a third is available for publishing, and it is hoped to obtain the manuscript for two others.

All of the papers have been illustrated by lantern slides.

Owing to the increasing attendance at the Section meetings, they have been held in various places, as the opportunity offered. Three have been held in the Society library, two in Myers Hall, and two in Gilbert Hall, Tremont Temple.

An experiment or innovation has been tried by serving a cafeteria supper at three of the meetings. The arrangements and price seemed to find popularity. By this means, it was also possible to begin the meeting a half hour earlier, which is of considerable advantage to out-of-town members.

The record of attendance is as follows:

Date	Attendance.	
	Dinner.	Meeting.
March 3, 1915 (annual meeting).....	36	61
November 3, 1915 excursion)	..	64
November 3, 1915.....	..	32
November 24, 1915.....	..	54
December 1, 1915.....	90	113
January 5, 1916.....	80	122
January 10, 1916.....	..	65
February 2, 1916.....	32	38

Average attendance at seven meetings, excluding the November excursion, was 69.

Five new members have been added during the year, making present total membership of the Section 174, of whom 9 are members of the Sanitary Section only, 4 are juniors and 1 an associate.

Arrangements have been made for a meeting, April 5, on the subject, "The Design and Use of Catch Basins." It is hoped to make this an experience meeting that will be valuable to all.

Preliminary arrangements have been made for a meeting in May on sanitary and hydraulic work in Hawaii.

It is recommended that the Board of Government of the Society be requested to consider and, if possible, take measures to provide for definite quarters where the meetings of the Sanitary Section may be held.

It is suggested that when the next notices are sent to members of the Society concerning a Section meeting, that an invitation be extended to non-members who are interested in sanitary matters to affiliate with the Section.

It is recommended that the incoming Executive Committee be requested to consider the advisability of the appointment of a special committee to standardize the nomenclature and technical terms of sanitary engineering or such branch thereof as they may deem advisable.

Respectfully submitted for the Executive Committee,

FRANK A. MARSTON, *Clerk.*

BOSTON SOCIETY OF CIVIL ENGINEERS.

REPORT OF THE COMMITTEE ON SOCIAL ACTIVITIES.

BOSTON, MASS., March 15, 1916.

TO THE BOARD OF GOVERNMENT, BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen,—The Committee on Social Activities, appointed by you in the spring of 1915, has the honor to report as follows:

Five informal dinners have been held during the year, on May 19, October 20, November 17, December 15, 1915, and January 26, 1916. A joint excursion and dinner with the New England Water Works Association, including ladies, was held on June 16, 1915. No informal dinner was planned for February, 1916, on account of the joint annual dinner of the mechanical, electrical and civil engineers, which came during that month. The informal dinners have in every case preceded the regular meetings of the Society.

The detail record of attendance at these dinners and the excursion is:

Date.	Members.	Guests.	Total.
May 19, 1915.....	78	12	90
October 20, 1915.....	83	40	123
November 17, 1915.....	75	20	95
December 15, 1915 (ladies' night),	77	41	118
January 26, 1916.....	73	22	95
Average attendance at the dinners.....			104
Average attendance, 1914-1915 dinner.....			84
Gain in average attendance.....			20
Percentage of gain in attendance, about.....			24%
Average attendance of members, 1915-1916.....			77
Average attendance of members, 1914-1915.....			66
Gain in average attendance of members.....			11
Percentage of gain in attendance of members, about			17%
Joint excursion, June 16, 1915:			
	Members.	Guests.	Total.
Attendance.....	146	74	220

The May 19 dinner was held at the City Club, with Mr. Harrison P. Eddy as toastmaster.

The June 16 excursion was held at Pemberton. On this occasion, the Society's baseball team defeated the New England Water Works Association team, 20-7, winning the first championship of the annual series and the coveted medals. Mr. George F. Merrill acted as toastmaster at the dinner in the Pemberton Inn following the game.

As a record, the box score of the game is presented herewith:

BOSTON SOCIETY C. E.

	R.	H.	P.	A.	E.
Cashman, 2b.....	2	1	1	0	0
Bryant, ss., p.....	4	1	0	6	1
Andrews, c.....	3	3	11	0	4
Ambrose, cf.....	1	3	0	0	0
Sampson, p., ss...	2	2	0	6	0
Craig, rf.....	2	2	0	0	0
Coghlan, lf.....	3	2	0	0	0
Gammage, 3b.....	3	3	0	1	0
Wason, 1b.....	0	0	2	0	2

Totals..... 20 17 14*13 7

* Allen hit by batted ball.

N. E. W. W. ASSOCIATION.

	R.	H.	P.	A.	E.
Conley, 3b.....	1	0	2	1	1
Heffernan, 1b, c...	1	0	2	0	2
Glavin, c., 1b.....	1	2	7	0	8
Allen, ss.....	0	1	0	0	0
Hersey, p., c.....	2	1	0	5	1
Johnson, lf.....	1	2	1	0	0
McBride, rf.....	1	1	0	0	1
Sherman, cf.....	0	1	3	0	0
Mulque, 2b.....	0	0	0	0	1
Symond, p.....	0	0	0	3	0
Simmons, 3b.....	0	0	0	0	0

Totals..... 7 8 15 9 14

Time of game: 1.45. Umpires: James W. Rollins and W. S. Johnson.

The October dinner was held at the City Club, following a joint excursion to the new Salem water works with the New England Water Works Association in the afternoon. President Charles R. Gow presided and the entertainment was furnished by Scott & Bayrd, the famous two-man minstrel show, whose jokes were localized.

The November dinner was held at the City Club, with President Charles R. Gow as toastmaster. The principal guest and speaker of the evening was the Hon. Calvin Coolidge, of Northampton, lieutenant-governor-elect of Massachusetts, who spoke on the "Relation of the Engineer to the Public Service of the State." Mr. Frank W. Stearns, manager of Mr. Coolidge's campaign, was also a guest.

The December dinner was served in Chipman Hall by Jesse Dill. It was ladies' night and 41 were present to grace the occasion. Entertainment was furnished by Miss Katherine Kelley, a charming story-teller, and by Josaf Yarrick, a clever magician.

The January dinner was held at the City Club, with Mr. Charles H. Eglee as toastmaster. The honor guests and speakers of the evening were Ralph A. Stewart, Esq., of Choate, Hall & Stewart, who spoke on the "Relation of the Engineer to the Legal Profession," and Mr. Wilfrid Wheeler, secretary of the State Board of Agriculture, who spoke on the "Development of the Agricultural Resources of the State." It was at this dinner, also, that Mr. Henry A. Symonds read his now famous "Post-Mortems with St. Peter."

Mr. Edwin R. Olin has acted as "Choragus" at all of these dinners, and under his able leadership mass singing has continued to improve, becoming one of the pleasantest features of these social occasions.

The personnel of the committee has been as follows: Edmund M. Blake, chairman; Charles H. Eglee, Frederic C. H. Eichorn, Clarence T. Fernald, N. LeRoy Hammond, Laurence B. Manley, Edwin R. Olin, David S. Reynolds, Charles W. Sherman, Henry A. Symonds. We have continued to make every effort possible to bind the membership of the Society more closely together and to build up and foster a strong social spirit based upon good fellowship. We feel that our work is showing the most encouraging results, not alone as evidenced by the large increase in the average attendance at the dinners, but even more by the very evident gain in fraternal *esprit de corps*. We

believe that on the building up and encouragement of this social spirit will depend to a large extent the ultimate strength of our organization in the communities we represent, and we have sincerely appreciated the responsiveness of the membership to our past endeavors.

Respectfully submitted for the Committee,

EDMUND M. BLAKE,

Chairman Committee on Social Activities.

REPORT OF THE EDITOR OF THE JOURNAL.

BOSTON, MASS., January 25, 1916.

TO THE BOARD OF GOVERNMENT OF THE

BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen,—I have the honor to submit the following report on the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS for the year 1915.

The JOURNAL was issued monthly, except in July and August, ten numbers being issued and 1 200 copies of each number being printed. As there were 1 112 copies used for the December mailing list, and as about a dozen copies are used each month for samples and to cut up for editorial purposes, we have now no more than 75 spare copies of each issue left on hand. This is ordinarily an ample supply, but if the membership of the Society continues to increase, the number printed will have to be enlarged.

The JOURNAL contained 18 papers, discussions of 8 papers and 7 memoirs of deceased members. A total of 742 pages was printed in the ten issues, with 49 cuts and 5 inserted plates, at a gross cost of \$2 726.11. Although a considerable amount of new advertising was secured, the total amount in the December issue was slightly less than at the first of the year. The loss of two full-page advertisements accounts for most of this. The total receipts from advertisements, \$1 456.50, were, nevertheless, slightly larger than in 1914. Deducting this amount, together with the sums received for subscriptions and sales of JOURNALS, the total net cost of the JOURNAL was \$1 193.62, or an average of \$119.36 per issue. From the total might be deducted the balance of about \$8 credited to us at the post office, which would reduce the average net cost to about \$118.50 per issue. It is interesting to compare this average net cost of \$118.50 with the figure of \$177.80 for nine issues of 1914* and \$160 estimated by the Committee on Publication in 1913. As the number of pages printed was less in 1915 than in 1914, the average net cost per page offers a still better comparison. Based on the 1913 estimate, it was \$2.10, for nine issues in 1914 it was \$2.09, and in 1915 it was \$1.61.

This low cost per page is mainly due to two facts; that many of the papers published have not been illustrated and that the cuts for one of the well-illustrated papers were furnished by the author.

The details of the number of pages printed and of the costs are given in the accompanying table.

Respectfully submitted,

EDWARD C. SHERMAN, *Editor.*

*The last nine issues of 1914 are used for comparison, as the January number was an exceptionally expensive one. See Report of the Editor in JOURNAL, April, 1915.

PROCEEDINGS.

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Month.	PAGES OF			No. OF		COST OF							
	Pa-pers.	Proc.	In-dex.	Adv.	In-serts	Cuts.	Adv'ts.	Reprints.	Postage, Wrapping and Mailing.	Editing.	Comms. on Adv'ts.	Editor's In-ci-dentials.	Copy. and Revenue Tax.
Jan.	48	16		18	2	\$160.93	\$19.43	\$10.00	\$18.10			\$0.57	
Feb.	42	16		18	0	173.80	21.91	10.00	20.70			.43	
Mar.	44	14		18	4	148.30	21.15	9.00	28.38		\$15.00	.33	
Apr.	34	39		18	0	209.15	17.35	18.00	19.52		22.50	.40	
May	34	14		18	5	141.89	21.23	10.00	19.77		8.75	.12	
June	58	10		17	12	277.70	18.01	27.50	25.91		9.37	.11	
Sept.	26	15		17	9	132.70	24.44	14.00	21.31		27.50	3.10	
Oct.	46	10		17	4	147.70	5.80	15.00	19.85		20.00	.45	
Nov.	18	15		18	6	103.75	25.18	7.00	30.77		10.62	.64	
Dec.	24	12	9	17	7	136.95	24.58	9.00	19.26		34.38	1.09	
Total	374	161	9	180½*	5	\$1 632.87	\$61.75	\$129.50	\$223.57†	\$300.00	\$148.12	\$7.24	\$11.00

Total number of pages, 742.	Total gross cost.....	\$2 726.11
	Subscriptions.....	\$40.50
	Sales of JOURNALS.....	35.49
	Advertisers.....	1 456.50
	Total net cost.....	1 532.49
		\$1 193.62

* 198 pp. used. Not all set solid.
† Balance at post office, about \$8.

APPLICATIONS FOR MEMBERSHIP.

[April 4, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

COBURN, FRANK RUNDLETT, Watertown, Mass. (Age 23, b. Cambridge, Mass.) Student at Mass. Inst. of Technology during year 1910-11. From 1911 to 1912, inspector of construction with sewer department, Watertown, Mass.; from 1912 to August, 1914, in business with F. J. Maynard, under name of Maynard & Coburn, engineers and surveyors, Watertown; from August, 1914, to date, inspector in conduit department with Edison Elec. Ill. Co. Refers to E. L. Johnson, W. F. Learned, O. F. Mann, F. J. Maynard and W. B. Snow.

CYR, JOHN P., Nashua, N. H. (Age 28, b. Pembroke, N. H.) Graduate of Nashua High School; received technical education from correspondence courses in mechanical drawing and structural engineering. During fall of 1906, timekeeper and rodman for City of Nashua; during 1907 and 1908, with Engrg. Dept., City of Nashua, first as rodman and later as transitman; during 1909 and 1910, assistant engineer with Erwin O. Hathaway, U. S. Senior Highway Engr., Nashua; from 1910 to date, assistant engineer, City of Nashua; during fall of 1915, was supervising engineer for City of Nashua and Town of Merrimack on construction of reinforced concrete bridge. Refers to A. W. Dean, W. M. Foster, E. O. Hathaway and W. F. Sullivan.

HANNAH, THOMAS EWING, Boston, Mass. (Age 21, b. Fitchburg, Mass.) Student at Mass. Inst. of Technology, class of 1917; attended Mass. Inst. of Technology Surveying Camp during summer of 1915. Refers to C. F. Allen, C. B. Breed, J. W. Howard and C. M. Spofford.

HOLMES, HARRY EMERY, Everett, Mass. (Age 40, b. Medford, Mass.) Graduate of Tufts College, engineering department, class of 1899. From 1899 to 1901, with Metropolitan Water Department; during 1901, with State Board of Health; from 1901 to 1902, with Metropolitan Sewer Department; during 1903, with City of Medford, city engineer's office; from 1904 to 1905, with W. N. Pike & Sons, building contractors; from 1906 to 1909, resident engineer, with E. Worthington, on construction of sewers and water works; from 1909 to 1910, resident engineer in charge of sewer construction, with F. A. Barbour; from 1910 to 1911, with Town of Brookline, engineer's office, in charge of sewer and road construction; from 1911 to date, with Massachusetts State Board of Health. Refers to E. M. Blake, H. H. Chase, F. A. Barbour, C. R. Gow, A. D. Weston and R. M. Whittet.

NAWN, LEO JOSEPH, Roxbury, Mass. (Age 21, b. Boston, Mass.) Educated in Boston public schools, Stone and Volkman preparatory schools and at Worcester Academy. During part of summer of 1911, clerk on underground conduit construction; summers of 1912, 1913 and 1914, sub-foreman for Hugh Nawn Contracting Company on construction of Boylston Street subway; from September, 1915, to date, clerk and sub-foreman for the same firm. Refers to J. H. Coghlan, F. P. Donovan, G. W. Lewis, Hugh Nawn and L. L. Street.

LIST OF MEMBERS.

ADDITIONS.

BEAN, THOMAS W.....	Turners Falls, Mass.
CROSS, RALPH U.....	Delta Upsilon House, Tufts College, Mass.
HOOD, RALPH D.....	50 Merrimack St., Haverhill, Mass.
HOWARD, DAVID R.....	241 Winter St., Woonsocket, R. I.
LUTHER, ROYAL.....	Box 467, Portland, Me.
PEABODY, DEAN, Jr.....	128 Summer Ave., Reading, Mass.
PEACOCK, FRANK E.....	535 Newbury St., Boston, Mass.
WHITNEY, RALPH E.....	84 Huntington Ave., Boston, Mass.

CHANGES OF ADDRESS.

ARMSTRONG, KENNETH P.,	care Interstate Commerce Comm., Div. of Valuation, Eastern Dist., Washington, D. C.
BESSEY, ROY F.....	Care Nichols Copper Co., Laurel Hill, L. I., N. Y.
BROWN, WM. A.,	111 Devonshire St., care H. S. Kimball, Boston, Mass.
DENLEY, ALFRED N.....	50 Cutting St., Winchester, Mass.
DRUMMOND, WM. W.....	Ft. Moultrie, Moultrieville, S. C.
EISNOR, JOHN J.....	41 Medford St., Medford, Mass.
FERRIS, RAYMOND W.....	33 Orchard Road, Akron, Ohio
GROVER, ARTHUR C.....	55 Evergreen St., Rutland, Vt.
HARRINGTON, WALTER.....	629 So. Broadway, Los Angeles, Calif.

KENDALL, THEODORE R.....	Box 116, Gatun, C. Z.
LEARY, CHARLES A.....	36 Beach Ave., Swampscott, Mass.
LOVIS, ANDREW M.....	Room 212, State House, Boston, Mass.
NEGUS, ARTHUR I.....	Box M, East Bridgewater, Mass.
SAVAGE, J. DANA.....	Commercial Bldg., Woonsocket, R. I.
SHEDD, GEORGE G.....	167 Myrtle St., Manchester, N. H.
SNOW, LESLIE W.....	8 Story St., Cambridge, Mass.
SOKOLL, JACOB M.....	129 Cumberland St., Cumberland Mills, Me.

DEATH.

LEAVITT, ERASMUS DARWIN.....	March 11, 1916.
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RESIGNATIONS.

(In effect March 15, 1916.)

ALEXANDER, E. PORTER	MOSHER, PERCIVAL H.
BUGBEE, JULIUS W.	OLSON, EDWARD F.
COLMAN, ARTHUR N.	PARLIN, RAYMOND W.
DODGE, SAMUEL D.	SCHWARTZ, SAMUEL
FERGUSON, HARDY S.	SMITH, ARTHUR H.
KENNEDY, FRANK L.	SNOW, WALTER B.
MANSUR, GEORGE W.	SPRAGUE, HARRY R.
MASON, FRANKLIN L.	TAYLOR, CHARLES M.
MORROW, CLARENCE E.	

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

351. Age 33. Graduate of Tufts College, class of 1906. Has had nine years' experience, chiefly on hydraulic and reinforced concrete design; experience includes $3\frac{1}{2}$ years as assistant engineer on design of Catskill Aqueduct and 3 years as hydraulic designer on important water-power development; is associate member Am. Soc. C. E. Desires position as hydraulic and reinforced concrete designer. Salary desired, \$1 800 per year.

352. Age 26. Student for four years (1906-1910) at Harvard Col. and

Graduate School of Applied Science, receiving degree of A.B. in 1909. Has had about six years' experience, chiefly on hydraulic development; has served in various capacities, including that of resident engineer on canal excavation, with some cofferdam and tunnel work; dam with sluice gates; and completion of hydro-electric station. Desires design, construction or management work along engineering lines.

353. Age 38. Educated in public schools. Has had about twenty years' experience as rodman, instrumentman, draftsman, sewer inspector and foreman of laborers. Desires position as inspector, transitman or draftsman.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Shorter Contributions to General Geology, 1915. David White.

Mineral Production of United States in 1914. H. D. McCaskey.

Structure of Berea Oil Sand in Summerfield Quadrangle, Ohio. D. Dale Condit.

Structure of Berea Oil Sand in Woodsfield Quadrangle, Ohio. D. Dale Condit.

Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1913 and 1914. Daniel L. Hazard.

Spruce and Balsam Fir Trees of Rocky Mountain Region. George B. Sudworth.

Water-Supply Papers 359, 372, 385, 397.

State Reports.

New York. Annual Report of State Engineer and Surveyor for 1914, Vols. I and II.

Wisconsin. Mineral Land Classification. W. O. Hotchkiss and others.

Wisconsin. Underground and Surface Water Supplies of Wisconsin. Samuel Weidman and Alfred R. Schultz.

Wisconsin. Soil Survey Bulletins 28 to 32 and 37 to 40, with maps. A. R. Whitson and others.

Municipal Reports.

Belmont, Mass. Annual Report of Water Commissioners for 1915.

Brockton, Mass. Annual Report of Water Commissioners for 1915.

Concord, Mass. Annual Report of Board of Health for 1915.

Concord, Mass. Annual Report of Road Commissioners for 1915.

Concord, Mass. Annual Report of Water and Sewer Commissioners for 1915.

Detroit, Mich. Annual Report of Water Commissioners for 1915.

Laconia, N. H. Annual Reports of Board of Public Works for 1915.

Manchester, Mass. Annual Reports of Sewer Commissioners for 1914 and 1915.

Peabody, Mass. Annual Report of Commission of Public Works for 1915.

Plainfield, N. J. Annual Report of City Officers for 1915.

Reading, Mass. Annual Report of Water Commissioners for 1915.

Rutland, Vt. Annual Report of City Officers for 1915.

Wellesley, Mass. Annual Reports of Water and Municipal Light Commissioners for 1915.

Westfield, Mass. Annual Report of Municipal Light Board for 1915.

Miscellaneous.

Industrial Arts Index for 1915.

International Engineering Congress, 1915: Transactions. — Panama Canal, Vols. I and II.

LIBRARY COMMITTEE.

Corporation. The contractor has continued to assemble plant and materials, including granite for the lining of the dock. The construction of the cofferdam has continued, and dredging of about 260 000 cu. yds. has been done to date.

Wollaston Yacht Club Channel. — Dredging at the Yacht Club Channel at Wollaston has been resumed. The total amount dredged to date is about 75 000 cu. yds. of material.

Extension of Northern Avenue. — The proposed extension of Northern Ave. from its present terminus near the Commonwealth Pier 6 to the dry-dock will provide a main line of travel from the city to the dry-dock. The Directors propose to build a portion of this by the construction of about 1 000 ft. of timber bulkhead, back of which may be received and dumped cinders and other suitable material as foundation for the roadway. Bids for the construction of this bulkhead will be received at an early date.

Boston Transit Commission. — *Dorchester Tunnel.* — Descriptions of Section D, E, G and H were printed in the JOURNAL in October and December, 1915.

Section D includes the station under Dewey Square, to be known as South Station Under. The interior finish on the walls consists of terrazzo and mosaic tile, above which is white Portland cement plaster, which is nearing completion. Escalators of the cleat type are being installed and shelters of polished granite and concrete are being erected over the entrances and exits of the station. Doors, handrails and other items of station finish are under construction.

In Section E both shields are under the channel, the one for the easterly tunnel being within about 500 ft. and the one for the westerly tunnel within about 900 ft. of the northerly end of the section, where they will meet the completed tunnel at the easterly end of Section D under Summer Street. About three fourths of the construction of Section E is done.

On Section G, construction by the tunnel method of the 3 ft. by 5 ft. and 4 ft. 9 in. intercepting sewer in Dorchester Ave. is in progress.

The pump well at B St. is completed, and the excavation

for the incline and for the tunnel by open cut between West Fourth and B Sts. in Dorchester Ave. is in progress. Tongued and grooved sheeting is being driven.

Boston Elevated Railway Company, Bureau of Elevated and Subway Construction. — *Egleston Square Station.* — Work on the changes to the Egleston Sq. Station is under way. Contracts for the steel work have been awarded and work upon the foundations, drainage and track work is about to begin on the site of the old Egleston Sq. car barn adjacent to the Egleston Sq. Station. A prepayment area is to be established.

Everett Extension. — Contract for the foundations for the Mystic River Bridge and Viaduct, and reconstruction of Malden Bridge, has been awarded to the Hugh Nawn Contracting Company, and active construction is about to begin.

The Fore River Shipbuilding Co., Quincy, Mass., has the following work in progress:

Seventeen submarine boats for the U. S. Government.

One submarine for the Spanish Government.

Three torpedo boat destroyers for the U. S. Government, *Tucker, Sampson* and *Rowan*.

Four oil boats for the Texas Co.

Three molasses boats for the Cuba Distilling Co.

Five freight steamers for the Luckenbach Co., Inc.

One tank steamer for the Argentine Government.

Two steel tank steamships for the Petroleum Products Co.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

Sudbury Dam Hydro-Electric Plant. — Two 24-in. turbines have been set in place, and the 900 K. V. A. generator has been delivered. The overhead transmission line is being erected.

METROPOLITAN PARK COMMISSION. — *Charles River Reservation.* — The work of building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, is in progress. A. G. Tomasello, contractor.

Plans are being prepared for bridge over the Charles River at Commonwealth Ave., between Newton and Weston, and bids will be asked for the work about the first of April.

Work of excavating channel of Charles River from Elm St. to Bleachery Dam, Waltham, is in progress. John R. Burke, contractor.

Alewife Brook Parkway. — Bids were received on March 27 for surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard.

Furnace Brook Parkway. — Work of construction of parkway extension from Quincy Shore Reservation to Hancock St. is in progress. John Cashman and Sons Company, contractor.

Work of building reinforced concrete girder bridge across Blacks Creek, for Furnace Brook Parkway Extension, is in progress. Hugh Nawn Contracting Company, contractor.

Mystic Valley Parkway. — Work of excavating the channel of Aberjona River from Boston & Maine Railroad Bridge to Waterfield Street is in progress. Coleman Brothers, contractors.

Old Colony Parkway. — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

DIRECTORS OF THE PORT OF BOSTON. — *Reclamation of Flats at East Boston.* — Under contract with the Bay State Dredging and Contracting Co. a portion of the bulkhead has been constructed, and 75 000 cu. yds. of filling placed adjacent to and along the axis of the bulkhead preliminary to driving the sheeting. This material has been dredged from the northerly side of the anchorage basin, east of the main ship channel.

The Directors received bids on March 6, 1916, for dredging and depositing 1 000 000 cu. yds. of material upon an area of State Flats north of the bulkhead now under construction. Prices per cu. yd. ranged from \$0.1547 to \$0.1875. The contract was awarded to the lowest bidder, the Atlantic, Gulf & Pacific Co. of New York, on March 14, 1916, and approved by the Governor and Council on March 21, 1916.

This material will be deposited by the hydraulic process and will reclaim about 35 acres of flats. The source of this material is a receiving basin already maintained northwest of Governors Island, and into which have been deposited, by scows, about 600 000 cu. yds. of material dredged from various parts of Boston Harbor.

In addition to this material, the Directors propose to deposit in this basin for rehandling about 450 000 cu. yds. of material to be dredged from Mystic River under another contract at the rate of about 80 000 cu. yds. per month.

Mystic River Dredging. — On March 6, 1916, bids were received for the excavation of 450 000 cu. yds. of material from a large shoal in Mystic River, westerly from Chelsea Bridge. The prices received varied from \$0.1185 to \$0.218 per cu. yd. The contract was awarded to the lowest bidder, the Maryland Dredging & Contracting Company of Baltimore, on March 7, 1916. The Governor and Council approved of this contract on March 21, 1916.

The depth of water to be obtained will be 30 ft. at mean low water. The material excavated may be disposed of by dumping within a receiving basin located northwesterly of Governors Island.

Dry Dock. — Some progress has been made on work at the dry dock, under contract with the Holbrook, Cabot & Rollins

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

ADDRESS AT THE ANNUAL MEETING.

(March 15, 1916.)

By CHARLES R. GOW, PRESIDENT, BOSTON SOCIETY OF CIVIL ENGINEERS.

It is sometimes interesting, as a subject of reflection, to compare achieved results with original expectations, and the outcome of such cogitation is often disappointing in effect.

In reviewing the work of our Society for the year now drawing to a close, I must confess that the unaccomplished tasks appear, by comparison, to be more impressive in character and in number than do the actual attainments realized.

That there still remains an abundant supply of promising suggestions for the further improvement and perfection of our organization I can readily attest, and for the purpose of recording some impressions of this nature which come to mind, I am prompted to refer rather briefly to certain features affecting the operation of our affairs which might well be the subject of additional consideration and discussion.

My observations have led me always to believe that the chief aim of a society of this character should be to procure the freest possible interchange of knowledge, opinions and ideas among its members. This may be accomplished in at least two ways, — by means of written papers, formally or informally presented and subsequently published with such discussions as they elicit; or by means of social intercourse among the members,

thus affording opportunity for verbal discussions of specific problems and topics. The exchange of personal experiences thus resulting is bound to prove invaluable to the participants.

It cannot be said that either of these methods has yet been developed to a satisfactory degree in the administration of our Society functions.

With a membership of approximately one thousand engineers, representing as it does every branch of the profession, there is bound to exist a collective fund of engineering information and experience which, if it could be made mutually available, would without question result in a wonderful advancement of our organization and of the profession as a whole.

With an occasional notable exception, it has not been the general practice among our members to give sufficiently of time and ability to render the service which the interests of the Society demands of them if this, its most important feature, is to be adequately developed and extended.

It is undoubtedly true that those members who are best qualified to contribute such information are often so preoccupied by reason of business demands as to render duties of this nature a serious burden. Nevertheless, it is to this source the profession must look for assistance if advancement is to continue, and it should be accepted as an obligation morally imposed, that even at a considerable sacrifice, members are individually responsible for the general propagation of engineering information and knowledge.

Regarding the possibilities for disseminating such knowledge through the medium of social intercourse, it is to be noted that, thanks to the very efficient and energetic work of the past two years on the part of the Committee on Social Activities, and especially of its most capable and enthusiastic chairman, Mr. E. M. Blake, our members have enjoyed the privilege of "rubbing elbows" with their fellows frequently and establishing a more intimate familiarity with them than has heretofore been possible. There can be little question of the genuine advantages of a social, educational and business nature which accrue to those who accept the opportunities thus afforded to extend acquaintance-ship among their fellow-engineers.

The average engineer is not a good "mixer," as the term is generally understood, even among his associates, and it is indeed unfortunate for the engineering profession that this is so. It is difficult to determine the cause of this seeming deficiency which so many times appears to operate as a handicap, not only upon the individual but also upon engineers collectively. There appears to exist some phase in the development of the technically trained mind which produces a serious and somewhat reticent trend of thought and action. It was for the purpose of breaking down in a measure this tendency toward reserve that the Society introduced the practice of holding frequent pre-meeting dinners, and in addition to afford members facilities for individual discussions and intercourse which is impossible at formal meetings. I feel thoroughly convinced that this policy on the part of our Society has brought valuable results, and there is ample evidence of increased interest on the part of our members and a general improvement in Society spirit.

Not at least until engineers as a body have learned fully to appreciate the qualities of each other may we expect the general public to become impressed with their attributes.

In other words, while the engineering profession is concerned with the reason for the seemingly low estimate which the public in general sometimes places upon engineering advice, we overlook the fact that our own members frequently manifest a surprising lack of confidence in the opinions of their associates on common subjects of engineering discourse. If, therefore, we are ever to expect a respectful recognition on the part of the public of the right of engineers to solve engineering problems, there must first come some indication of substantial unanimity among the members of the profession itself as to common engineering questions. I contend that this result can only be brought about through a thorough discussion between engineers of their many problems, aided by a presentation of the combined experience of all individuals who are in a position to contribute.

This is not the first time that this subject has been called to your attention by a retiring president, and I trust that its principles may be restated at frequent intervals until such time as a majority of our members accept its importance as an issue.

Closely related to the preceding subject is that of the necessity for mutual toleration by our members of the opinions of their fellows. Without this attitude of mind it will be useless to expect coördination of thought and action among engineers. If, in place of cynical criticism of that which appears erroneous, useless or absurd in the arguments of our contemporaries, we search for the thread of truth, which almost invariably can be discerned if we seek it, and if we then submit to temperate and patient argumentative discussion our differing points of view, it will usually be found possible to arrive eventually at a point where conflicting beliefs may be more or less reconciled to the advantage of the participants.

Is not this the spirit which engineers should manifest if they sincerely desire to elevate their profession above the level of an individual competitive struggle for existence? I would ask our members seriously to consider whether each is contributing his share of effort in these directions, and whether they may not in fact be denying themselves benefits in the nature of wisdom and knowledge which unknown to them may exist in the reasonings of their fellow-workers whose opinions they disdain.

The rapid advancement in the sciences during recent years, the increased demand for technical skill in promoting the industries of a prosperous and growing nation, and the consequent wide diversity of effort into which the engineer has been called, have resulted in a strong tendency towards specialization on the part of the individual and a grouping into classes according to some particular line of endeavor or interest. This situation has resulted practically in a changed conception of the significance of the title of civil engineer. Nevertheless, few engineering projects of magnitude are executed to-day which do not require the combined services of men representing several if not most of the scientific callings, and so there is now apparent a more or less genuine recognition of the necessity for regrouping the diversified branches of the technical professions under a common leadership, because it is becoming obvious that, despite the apparent fundamental differences in the individual trend of thought and activities, the accomplishment of the final objective is dependent not upon one but upon a proper combination of many different lines

of effort. Thus in the conduct of such enterprises as the construction of the Panama Canal, the great New York Water Supply System and the several subway enterprises for our large cities, we observe the surveyor, the draftsman, the structural designer, the electrical expert, the mechanical adept, the architect, the geologist, the chemist, the construction supervisor, and last but not least the contractor, — all working shoulder to shoulder, each contributing his special qualifications in a common cause, and under the direction and leadership of the chief engineer whose function it is to coördinate and harmonize the several abilities of his subordinates, to the end that the completed structure may reflect in its perfection of detail the combined wisdom, judgment and forethought of every branch of the profession.

In recognition of this principle, our Society has already taken steps looking to a more universal intercourse with other closely allied societies. Arrangements have been effected whereby a joint standing committee, comprised of nominees from our Society, and members similarly appointed from the local sections of the mechanical and electrical societies, will coöperate for the purpose of promoting a closer relationship between the three bodies and for devising means which will permit joint action in many of our activities.

It is to be hoped that this movement for the unification of engineers and engineering will continue to grow until the artificial barriers which have been allowed to separate our organizations in the past will be largely obliterated.

Much has been said in recent times concerning the desirability of engineers and engineering societies participating individually or collectively in attempts to influence or direct public affairs, and in a minor way our Society has taken some steps in this direction by the creation of a legislative committee whose function it is to observe attempted legislation on questions affecting engineering and to bring to the Society's attention unwise or inimical proposals for changes in law. In addition, representatives of our Society have been assigned at times to confer with and advise public boards, at their request, on matters of a technical nature. Undoubtedly much more can be ac-

completed along these lines to the advantage both of the general public and ourselves.

It has been urged at times that the Society should be made a factor in the community for the exercise of a certain measure of control or direction over administrative affairs of a public character so far as such matters are of an engineering nature or affect the profession or its work.

There probably never was a time in the history of our nation when there was greater need than at present for a wise and judicious oversight of the detailed actions of our governmental representatives; but the need which exists is for constructive assistance rather than for destructive criticism. There is already a great surplus of voluntary advisers who apparently seek to usurp the administrative functions of our several appointive and elective officials, leaving to those parties only the responsibility for such failures as may ensue. This I contend is an interference with good government and not an assistance. The need rather is for responsible bodies in the several communities, composed of individuals who from their nature and position command the confidence and respect of a majority of good citizens, who will analyze in a purely scientific, impartial and dispassionate manner such public acts and contemplated actions as they may by knowledge and experience be qualified to pass judgment upon, and will render their decisions in accordance with the actual facts, ascertained only after an exhaustive consideration of all the evidence available, regardless of prevailing prejudice, personal effect or political consideration; who will strongly defend public officials against irresponsible criticism whenever they are found to be right, even though such officials may otherwise be lacking in popular favor; who are capable of looking on matters with a broad perspective, and who are willing even to suffer personal loss if the contemplated act is for the good of the greater number of people.

I must confess that this outline of requisites presupposes an ideality not usually realized in present-day activities; but I will contend that if such attributes exist in the membership of any organization it may be expected to prevail among those composed of engineers. It is possible, therefore, that such a

field of usefulness may be open to our Society, but such a departure should, in my opinion, be made with extreme caution.

When we have arrived at a position which warrants assurance that a majority of our members are constituted mentally and morally so as to guarantee immunity from the danger of personal bias or attempted individual aggrandizement; when we display a disposition always to accord full credit to its proper source, even when by so doing it may be necessary to reward those whom personally we dislike; when we appear disposed to sink our own interests and welfare into obscurity and stand for a given principle, at a personal sacrifice; and when we are able to brush aside all outward impressions of an indefinite and inconclusive character and form our judgment upon ascertained facts only, — then may we feel justified in interfering with administrative matters of a public or semi-public nature for the benefit of the community at large.

In the meantime, there is much useful work of a public character to which we may, if we wish, contribute. Our membership should be made available at all times to such public officials and commissions as may require expert opinions or scientific determination of facts.

Complicated questions are constantly arising in almost infinite variety for consideration and solution by public boards and officials. It is reasonable to assume that no individual, or single group of individuals can be presumed to possess the requisite diversity of knowledge to solve correctly all such problems without special outside assistance. So far as these questions may relate to technical subjects, there would seem to be no sound reason why the combined wisdom of our membership should not be put at the public's disposal, and it should become the common practice of governmental administrators to call upon this or other organizations especially qualified by education and experience to advise upon specific matters, for such expert analysis as the occasion demands.

This service should be rendered without money compensation, and solely for the good of the community. I do not wish to be understood as advocating that such service should be made to supplant the paid engineering departments of our several public

administrative divisions. On the contrary, the aim should be to strengthen the efficiency of those departments by removing uncertainties and reducing the possibility of error. Here again good judgment will be required in the determination of the nature of the service which properly can be rendered without conflicting with the ethics of our profession. It would, for example, create a somewhat delicate situation if a committee of our Society were called upon to review the acts of a fellow-engineer. Under such circumstances probably nothing further than a clear presentation and analysis of the facts in issue could with propriety be embraced in any formal report, leaving the conclusions to the responsible parties. Under somewhat different circumstances, however, it might be possible to accompany such a report with definite recommendations.

An opportunity for public service of vast national importance is presented by recent agitations for the establishment of volunteer engineering corps throughout the country which would cooperate with the army engineers in planning national defenses and in preparing to execute such plans in case of emergency. Here there is offered a practical suggestion possessing great possibilities which can and should appeal to every engineer who styles himself a patriot. The organization within our ranks of a volunteer engineers corps will, without doubt, reflect in a practical way the value of our Society in a public as well as engineering sense.

Our membership has not changed materially since a year ago, at which time a marked increase was noted. I would recommend that serious attention be given to the question of the desirability of encouraging further increase beyond the natural additions which come from voluntary applications. A further substantial increase in our numbers is not in any way essential to the Society's welfare, and it is possible that it might prove detrimental. Quality of membership is far more important for the continued advancement and prosperity of our Society than is quantity. If our membership is of a character which commands the respect and attention of the profession at large, there need be no apprehension as to the future of our numbers. A membership that is drafted is less likely to be appreciative of the

honor than one which is attracted by the superiority of personnel and the general excellence of professional results attained.

I suggest, therefore, that from this time consideration be given to plans for attracting new members by means of an established higher standard and broadened activities and that a more careful discrimination than now prevails be applied in the case of future applicants.

The Society is extremely fortunate in possessing ample financial resources from which to meet its current obligations, together with a rapidly growing surplus. This condition denotes a healthy state of our business affairs, and one which it is to be hoped will continue in the future.

Having established this favorable situation it would be most unfortunate for the continued welfare of the Society were we even for a single year to permit an expenditure in excess of income unless for an exceptional or unusual purpose. However, it appears, on the other hand, to be at least debatable whether any desirable activity which might tend to promote the Society's advancement should be ignored, sacrificed or curtailed for the sole purpose of increasing the amount of idle funds, which have now reached the total of \$37 475 and which are growing yearly at an accelerated rate. Financial considerations which govern the actions of individuals or business enterprises may have little bearing upon the economic treatment of an organization such as ours.

It will be possible by a somewhat more liberal policy toward appropriations to create new activities which may greatly enhance the interest of our members and the importance of the Society. Should not considerations of this nature precede the desire for accumulation of finances for a vague, uncertain or indefinite future purpose?

I wish to impress upon you my thorough conviction that although there is undoubtedly much room for improvement in some of our Society affairs, we nevertheless are in a position to congratulate ourselves upon our splendid present standing and brilliant future prospects. Our general condition was never more promising than at present, and with a proper degree of loyalty, interest and progressiveness on the part of our members we may

look for continued improvement and increasing importance in the community.

In conclusion, I wish to express my sincere thanks to those who have held me in sufficient esteem to honor me with the position of president during the past year, a privilege which I have keenly enjoyed and which I deeply appreciate. It will always be my earnest endeavor to continue to work for the welfare of the Society in the future as in the past, with the feeling that what is good for the engineering profession as a whole is also of advantage directly or indirectly to me as an individual member thereof.

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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THE SPILLWAYS OF THE PANAMA CANAL.

By EDWARD C. SHERMAN,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented February 16, 1916.)

THE adoption of the high-level type of canal at Panama, with the consequent impounding by earth dams of large quantities of water in lakes which are essentially enormous storage reservoirs, necessitated regulation by masonry spillways of very considerable capacities at Gatun and at Miraflores.

GATUN SPILLWAY.

The lake formed by the great dam at Gatun, with surface at 85 ft. above sea level, has an area of about 168 sq. miles and receives the discharge of the Chagres, the Trinidad and the Gatun rivers, draining a watershed of 1 320 sq. miles. While the Isthmus of Panama is not subject to violent storms accompanied by heavy rains, the ordinary precipitation of the rainy season frequently causes great freshets in the rivers.† Records

† Trans. Am. Soc. C. E., Vol. LXVII, p. 112.

NOTE. Some parts of this paper and some of the illustrations relating to the design of the spillways were included in a paper presented before the International Engineering Congress in San Francisco in September, 1915.

NOTE. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the JOURNAL.

* Of Rourke & Sherman, Consulting Engineers, Boston. Formerly Designing Engineer, Isthmian Canal Commission.

of the discharge of the Chagres at Bohio have been kept for many years, the engineers of the French canal company having secured invaluable run-off data, and from more recent observations it has been determined that the discharge of the combined streams, at Gatun, is about 1.62 times that of the Chagres at Bohio.

From the available data, it appeared that the maximum rates of discharge at Gatun which should be considered in designing the spillway were as follows:

	Sec.-Ft.
Maximum momentary rate.....	183 000
Maximum rate for 33 hours.....	137 500
Maximum rate for 48 hours	120 000

The area of the lake at its normal level is so great that, with a spillway discharging 120 000 sec.-ft., an inflow amounting to 183 000 sec.-ft. would cause the surface to rise only one foot in twenty hours, and an inflow of 137 500 sec.-ft., lasting thirty-three hours, would cause it to rise only 0.46 ft. in all.

On account of the possibility of the occurrence of a freshet exceeding in duration and rate of discharge any of which there is record, it was determined to provide a spillway capacity of 140 000 sec.-ft., with the lake at its normal level of 85 ft. above sea level. The designs of the lock walls and gates were based on the assumption that the lake level would seldom be permitted to rise more than 2 ft. above normal, to elevation 87, and, as a simple overfall dam without regulating gates would have to be about 3 miles long to discharge 140 000 sec.-ft. without exceeding a depth of 2 ft. on its crest, it was decided to construct the dam with its crest below the normal lake level and to hold back the water by means of steel sluice gates of the Stoney type. This permitted the construction of a dam of reasonable length which would give a large discharging capacity, not only when a freshet might cause a rise in the lake, but also with the lake at its normal level of 85 ft. above the sea, so that water might be drawn off in anticipation of freshets.

About midway in the length of Gatun Dam there was a rocky hill outcropping, which provided an excellent site for the

regulating works, affording a suitable foundation for the heavy masonry structure and being near enough to the locks to be easily defended in time of war. The extent of this available foundation determined in part the length of the spillway dam and, consequently, the elevation of the crest, which was placed at 69 ft. above sea level, or 16 ft. below normal lake level.

No data on the value of the coefficient of discharge for a dam with from 16 to 18 ft. depth of water on its crest were avail-



FIG. 1. GATUN SPILLWAY. SITE OF DAM.

able, the greatest head for which there was definite information being 7 ft., at La Grange dam in California. The effects of the unusual depth, the proposed shape of the crest and of the piers necessary to hold the gates, were therefore studied with considerable care and it was estimated that in the formula $q = C(L - 0.2h)h^{1.5}$ the coefficient would not be less than 3.0, and that it would probably be about 3.5.

With Gatun Lake at its ordinary elevation of 85 ft. above sea level, giving a depth of 16 ft. on the crest, and with $C = 3.47$,

q becomes 10 000 sec.-ft. from each 45-ft. gate opening. If the lake is at its maximum elevation, giving a depth of 18 ft., q will be 10 000 sec.-ft., with $C=3.0$. It seemed reasonable, therefore, to expect that such a discharge would occur without causing the lake to rise above the 87-ft. level, and the spillway dam was accordingly designed to have 14 of the 45-ft. openings, insuring the desired total capacity of 140 000 sec.-ft. The total clear



FIG. 2. GATUN SPILLWAY. LAKE DISCHARGING OVER SITE OF DAM AND THROUGH CHANNEL.

crest length is 630 ft. and the total distance between abutments is 760 ft.

It is interesting to note that recent measurements of the discharge from a single opening showed that about 11 000 sec.-ft. were passing when the depth on the crest was 17 ft. For this discharge and head the value of C is 3.94, and if this is the true coefficient the total capacity of Gatun Spillway at high water is 174 000 sec.-ft., which is larger than is likely ever to be required.

In his paper on "Engineering Lessons from the Ohio Floods,"* published in our JOURNAL in 1914, Mr. John W. Alvord showed a curve giving values of C for heads up to 11.5 ft. Extrapolating on that curve would give a value of about 3.6 for a head of 16 ft.

Although the crest of the dam was made of a form which, while providing seats for the Stoney gates and for the caisson needed to permit repairs to be made, would facilitate the flow



FIG. 3. GATUN SPILLWAY. MIDDLE SECTION STOPPED AT ELEV. 50. OPENINGS THROUGH DAM FOR CONTROL OF LAKE DURING CONSTRUCTION.

of the water, the design of the downstream face was controlled by the principle that the nappe should adhere to the masonry to prevent air from entering under it to cause chattering and the consequent lifting action, which, with such an enormous quantity of water, might be dangerous to the structure.

In determining the profile of the dam, it was not considered necessary to use the velocity of flow through the orifice which

* JOURNAL Boston Society of Civil Engineers, Vol. I, p. 85.

exists under a gate while it is being opened, as the amount of water would then be too small to do any harm. At the same time it was not considered safe to use the lower velocity of flow over the weir which exists when the gate is fully opened, as a large amount of water would pass during the last stages of opening and the first stages of closing a gate and while the gate was still immersed on its lower edge. It was assumed that the horizontal velocity, due to the gate being open 6 ft., was a reasonable one to use, and the upper part of the downstream face of the dam was made a parabola, convex upward, of the form $h^2 = 42v$, this being slightly flatter than the natural curve of the overflowing stream. To turn the water back to the horizontal direction at the toe of the dam without serious disturbance, the lower part of the face was designed to be a circular curve of long radius, concave upward.

The general plan and the cross-section of the spillway dam which was adopted and built are shown in Plates I and II. The crest is divided into openings or bays by piers which extend above the crest high enough to permit the Stoney gates to be raised clear of the water and to allow the safe passage of drift. It is not expected, however, that any considerable amount of drift will reach the spillway, for in a lake so great and of such irregular contour as that formed by the Gatun Dam, the currents towards the outlet will ordinarily be inappreciable except in the immediate vicinity of the spillway. The course of floating substances will therefore be determined by the wind rather than by the current, and they will be stranded on the shores.

The floor of the spillway channel below the dam is 10 ft. above sea level, so that there is no pool to serve as a cushion for the overflowing water, which, having fallen 75 ft., has a velocity of about 60 ft. a second. Such a velocity would be dangerous to the floor of the channel, and the depth of the stream could not be determined, since, under such conditions, the great initial velocity and correspondingly small cross-section may be retained, or, without apparent reason, the depth and area of section may increase and a less velocity be assumed, or stationary waves may be formed, the velocity of the stream being

different at different points in the channel.* This uncertainty made it seem essential that some positive method should be devised for reducing the velocity of the flow at the toe of the dam so as to obtain a condition of uniform flow at a reasonable velocity in the discharge channel. It was not deemed safe to depend upon the convergence of streams from the curved crest towards the common center to destroy the energy created by the fall, and a system of baffles was consequently introduced in the



FIG. 4. GATUN SPILLWAY DAM. BAFFLE PIERS IN FOREGROUND. ENTRANCE TO MACHINERY TUNNEL IN DISTANCE.

floor just below the dam. A somewhat similar system of baffles had been used below the overflow pool at the Wachusett Dam, and a solid wall had been used for the same purpose below a dam in Utah.†

The water flowing over the face of the dam has a depth of about 6 ft. when it reaches the baffles, which are 9 ft. high.

* Proc. Am. Soc. C. E., September and November, 1915.

† Trans. Am. Soc. C. E., Vol. LXII, p. 49.

Striking them, it turns vertically upward and much of its energy is used in internal work and converted into heat. The stream immediately below the baffle piers has a depth of approximately 20 ft. and a velocity of about 20 ft. per second.

The spillway channel is 285 ft. wide and 960 ft. long, its length being such that the water is discharged beyond the limits of the earth dam at a point where erosion will do no harm. The concrete floor varies in thickness from 4 ft. at the upper end to 1 ft. at the lower end, except that in the apron immediately below the toe of the ogee and around the baffle piers, where the velocity of the overfalling water is reduced and great disturbances are caused, it is 12 ft. thick.

It seemed desirable to make some tests with a model to determine by actual experiment whether the proposed arrangement of baffles might be expected to accomplish the desired result. A model was made, therefore, on the scale of $\frac{3}{8}$ in. to a foot, the curved ogee section being made of concrete carefully placed between wooden battens sawed to the proper shape. The crest piers were of wood, grooved for wooden gates so that the discharge could be regulated at will. The baffles were wooden blocks, fastened to the floor with screws so that they might be moved about. The water supply was obtained from the drainage from the hydraulic fill in the interior of Gatun Dam, and a by-pass with gates made it possible to regulate the flow so as to get any desired depth on the crest. Experiments were made, first, with all baffles in place; second, with only the row of larger upstream baffles in place; and, third, without baffles. The tests without the baffles indicated clearly that it would not be desirable to omit them, as the converging streams of water formed a very large stationary wave at the upper end of the channel. With one row of baffles in place there seemed to be more disturbance than with two rows, while the results obtained with two rows of baffles in place indicated that they would give the desired results.*

The baffle piers as built are of concrete, like the rest of the structure, but they are heavily reinforced with steel rails and their upstream faces are armored with very thick, ribbed, iron

* *Engineering Record*, June 4, 1910.

castings, so that such drift as may strike them will not easily destroy them. If they are destroyed or badly damaged, they can be replaced or repaired in the dry season when no water will be discharged from the lake. (Plate III.)

Each crest gate weighs about $42\frac{1}{2}$ tons. It is essentially a steel frame, consisting of two end posts, four horizontal main girders, and three vertical cross girders with intercostals and braces. The frame is covered on the lake side with water-tight steel plates, butt-jointed with calked cover plates. The water pressure on the gate is transmitted from the end girders through equalizing rocker bearings and roller trains to cast-steel bearing plates set in the concrete of the piers. Cast-iron side plates are also set in the concrete piers to serve as bearings for bronze water seals at each end of the gate. The bottom contact of the gate is made on a babbitt seat.

These gates are operated electrically by machines installed in a tunnel extending throughout the length of the dam and beyond it, through the earth, to the vicinity of the power house on the east side of the discharge channel, where the control board is located. The gates are lifted by means of chains, attached to the ends, passing over sheaves on the tops of the piers; thence down through pipes in the masonry to the tunnel, where they are attached to vertical stems, threaded and engaged in the operating nuts, which are driven by worms at the ends of the main shaft, back geared to the motor. Counterweights, traveling in pits under the tunnel floor, are attached to the lower ends of the stems so that comparatively little power is required for operation.

The openings between the crest piers, above the gates, are spanned by steel foot-bridges which can be removed if necessary for the installation of new gates. Auxiliary hand operation is provided, so that means are available for opening the gates even though the electrical machinery should break down.

The spillway dam was constructed in the following manner: A cut was made through the hill which had been selected as the site of the spillway, and a concrete floor and side walls were put in except at the site of the spillway dam, where low piers were built in the channel to key the dam to the rock and to serve

for supports for such stop-planks or cofferdams as were necessary to shut off the water and permit the placing of concrete in the dam. (Fig. 1.) When the construction of the Gatun Dam had proceeded far enough to cause the closure of the natural outlets of the rivers, the slowly forming lake found a new one ready in this artificial channel. (Fig. 2.) It discharged through this channel during one rainy season. During the succeeding dry season the lake surface fell so low that the depth of water at

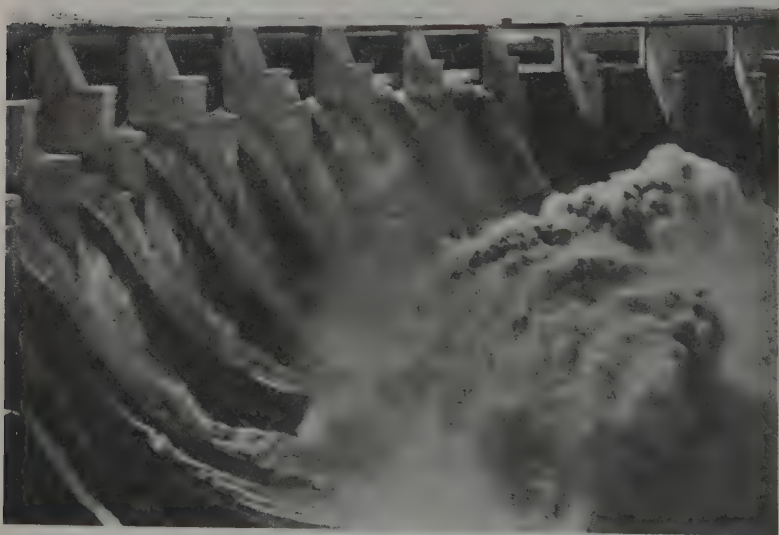


FIG. 5. GATUN SPILLWAY, WITH 7 OF 14 GATES OPEN, SHOWING EFFECT OF BAFFLE PIERS.

the side of the dam was only about 1.5 ft. The stop-planks were then easily put in between the piers, and the flow entirely stopped. The construction of the dam then proceeded, the piers being carried up ahead of the rest of the work. Then the ends of the dam were carried up to full height, while the middle section was stopped at elevation 50, so that under no circumstances might the lake rise so high as to interfere with excavation in Culebra Cut. (Fig. 3.) Although the lake did overflow

the temporary crest of the dam at elevation 50 in one great freshet which occurred during the following wet season, it was controlled most of the time by three low-level culverts, left through the body of the dam and provided with some of the sluice gates afterwards installed in the lock-filling culverts. (Fig. 3.) As soon as the work of excavation of the Canal permitted it, the middle section of the dam was completed to full height, the crest piers carried up, the gates and machinery in-



FIG. 6. GATUN SPILLWAY COMPLETED AND DISCHARGING ABOUT 75 000 SEC.-FT.

stalled, and the foot-bridge spans set in place. The low-level culverts were then closed at their upstream ends by heavy wooden gates, the steel gates were removed and the culverts filled with concrete. (Fig. 4.) The completed dam, with water flowing through seven of the fourteen gate openings, is shown in Figs. 5 and 6.

The concrete plant for Gatun Spillway, consisting of a dock, material platform, cement shed and mixer building, was

located on the old French canal, about 5 000 ft. away from the dam. The materials were brought to the concrete plant by water and the prepared concrete was hauled to the work by steam locomotives on a narrow gage railway. Each train consisted of two cars carrying two batches of two cubic yards each. They were run at about 25 miles per hour, and no difficulty was found in removing concrete from the plant as fast as it was mixed.

About 225 000 cu. yds. of concrete were used in Gatun Spillway, nearly all of it being a 1:3:6 mixture. Although there was a large amount of mass concrete, the difficult work in the piers raised the average cost to \$8.00 per cu. yd. The excavation amounted to 1 550 000 cu. yds., and it cost an average of about \$0.71 per cu. yd. Including operating machinery, gates, caisson and miscellaneous details, the total cost of the work was about \$3 450 000.

MIRAFLORES SPILLWAY.

The Miraflores Spillway, which serves to control the small Miraflores Lake, is located east of the locks and connects them with the rock ledges of the hills on that side. Although this spillway has some features like the corresponding ones at Gatun, the problem of design was a very different one owing to the peculiar conditions above the lake.

That such an accident as happened at the locks in the St. Mary's River* about five years ago may happen to the lock gates at Pedro Miguel is not impossible, and proper control of Miraflores Lake involves, therefore, not only passing the insignificant flow of the tributary streams, but the disposal of the large amount of water which would come down from the higher level of Gatun Lake through Culebra Cut should an accident permit an unobstructed flow to take place through one of the twin locks at Pedro Miguel.

Careful studies were made of the quantity which might be expected to flow into Miraflores Lake should this contingency arise, and the spillway which was designed with a capacity at

* *Engineering News*, June 17, 1909.

maximum permissible lake level of about 92 000 sec.-ft. is believed to be ample. The quantity which will flow into the lake is not susceptible to exact determination, as the judgment of the engineer determines the constants used in the formulas, and results ranging from 75 000 sec.-ft. to 116 000 sec.-ft. were obtained by different computers. It is probable that the true value lies between 90 000 and 100 000 sec.-ft., but, in case the inflow is found to be greater than has been predicted and greater



FIG. 7. MIRAFLORES SPILLWAY. COMPLETED DAM. POOL IN FRONT OF DAM IS ABOUT 25 FT. DEEP.

than the spillway dam can discharge, the filling culverts of the Miraflores locks can be opened to provide an additional capacity of some 25 000 sec.-ft.

The spillway dam is a straight concrete dam of ogee section with its crest 16 ft. below the ordinary level of Miraflores Lake. (Plate IV.) The crest of the dam is divided into eight bays, similar to those on the spillway dam at Gatun, the piers being

so designed that the caissons for closing off gate openings may be used interchangeably at both spillways. (Plate V.)

Although the tide in the Bay of Panama has a range of about 20 ft., a sill, or part tide dam, in the Rio Grande at Corozal, a few miles below Miraflores, prevents the water above it from falling with the tide, so that the surface of the pool below the dam varies only between elevations 6 and 10, the depth of water at the toe of the dam varying from 21 to 25 ft. (Fig. 7.) With a pool of such depth and of considerable area below the dam it did not seem necessary to use baffle piers, such as were adopted in the design of the Gatun Spillway, to check the velocity at the toe. Besides, while it would not be wise to omit provision for it, the accident that will make it necessary to utilize the full capacity of the Miraflores Spillway is a remote probability and may reasonably be anticipated only at extremely long intervals of time, and the amount of erosion at the toe of the dam, due to the discharge over it of such amounts as are necessary for ordinary lake regulation, will undoubtedly be very small.

The area of the watershed tributary to the lake is 66 sq. miles. From this it was estimated that a maximum run-off of 7 650 sec.-ft. might occur. Ordinary lake regulation was estimated to require a discharging capacity of about 3 000 sec.-ft., and, although it was at one time proposed to install subsidiary culverts through the dam so that the heavy crest gates might not have to be opened for this purpose, it was finally decided to omit them. It seemed better that the crest gates should be operated frequently, so that the men in charge might have experience in working and caring for the machinery and because every time a gate is raised an opportunity is afforded for examination of its condition and even for painting.

The machines for operating the gates are placed in a tunnel, running through the body of the dam from end to end, just as in the Gatun Spillway. As the flood that would be thrown into Miraflores Lake by the breaking down of a lock at Pedro Miguel would raise the lake level at the rate of a tenth of a foot a minute, and as the top of the earth esplanade around the locks is only 4 ft. above ordinary lake level, it is evident that after the accident happens the spillway gates must be opened promptly. The

ordinary manual control of the electric motors which lift them is therefore supplemented by an automatic self-starter, actuated by a float switch in a well in one of the abutments, connected with the lake so that when the water rises beyond a certain predetermined level the gates are opened.

About 75 000 cu. yds. of concrete, at an average cost of \$6.85 per cu. yd., were required in the construction of the Miraflores Spillway. Excavation amounted to some 166 000 cu. yds., and cost at the average rate of \$0.69 per cu. yd. The total cost of the work, including gates, operating machines, caisson and miscellaneous details, was about \$985 000.

FLOATING CAISSON.

Although it is expected that the crest gates of the spillways can ordinarily be painted when raised out of the water, it may happen that the work to be done is more extensive than can be accomplished in the short time that a gate can be left open, or it may be necessary to make repairs in the dry season when it is not desirable that any water be needlessly wasted. A floating steel caisson, similar in many respects to a dry-dock gate, has therefore been provided, so that work may be done on a crest gate behind its shelter. This caisson, which is merely a rectangular steel box provided with timber sills and keels so that it may fit tightly against the masonry, can be floated into its place behind the crest gate to be repaired and water admitted into it in sufficient amount to cause it to sink to its seat. Opening the Stoney gate a few inches will then permit the escape of the small amount of water between the gate and the caisson, and will cause an unbalanced pressure on the upstream side of the caisson which will force it tightly against the vertical seats and permit very little leakage.

Upon the completion of the work on the gate, water will be readmitted to the space between the gate and the caisson by means of a pipe passing completely through the caisson, and the latter will be pumped out and towed away, there being sufficient permanent ballast in it to make it float upright in the water.

Study was made of two types of construction, reinforced

concrete and steel. It was necessary to use longitudinal steel girders in either case, to span the long opening, and the first type, although called reinforced concrete, would have been so only in the use of slabs of that material as sheathing for those parts that would be inaccessible without docking. A preliminary design was worked out, but the all-steel caisson seemed preferable and was designed in detail. Sections of the latter and a side elevation with the sheathing removed to show the interior equipment are shown in Plate VI.

There will be no difficulty in painting the caisson, as it can be dry-docked in one of the locks of the canal when the lock gates are to be inspected or painted. It will be kept at a prepared anchorage ground, where the depth of water is such that, should sufficient leakage occur to cause it to sink, it will not go deep enough to prevent easy recovery.

RETAINING WALLS.

Rather high retaining walls were required at the sides of the approach channels at Gatun Spillway and at the sides of the discharge channel of Miraflores Spillway. Those at Gatun were 45 ft. high for a considerable part of their length, and as they had to withstand the pressure of the fluid hydraulic fill of the earth dam before Gatun Lake could be filled to help sustain them with water pressure on the front, the conditions were rather severe. The filling was assumed to exert a horizontal pressure equivalent to that of a liquid weighing 75 lbs. per cubic foot, but, at the same time, exerting an actual vertical weight of 125 lbs. per cubic foot in the horizontal steps at the back of the wall. These walls rest on a firm argillaceous sandstone, and under the given assumptions the line of resistance falls a little outside of the middle third, but the maximum pressure at the toe is only 110 lbs. per square inch. With the lake filled, the line of resistance is inside the middle third, and the maximum toe pressure is 62 lbs. per square inch. The base width is $27\frac{1}{2}$ ft., giving a ratio of base to height of .61.

GATUN SPILLWAY.
GENERAL PLAN OF DAM.



DISCUSSION.

MR. LOUIS K. ROURKE.* — In connection with the very able paper to which we have just listened I have not much to say except that the successful working of the Panama spillways since they have been put in operation is a tribute to the skill and training of our fellow-member, Mr. Sherman, who designed them.

The most spectacular thing in connection with the construction of this work was the damming of the river at Gatun and turning the water through the completed spillway channel. When the Americans took charge of the work at Panama, the Chagres River was flowing through three channels at the site of the Gatun dam. The most easterly one was the natural bed of the Chagres, the second channel was the sea-level canal which the French had dredged for a distance of fifteen miles inland, and the third channel was the west diversion, which was located to the west of Spillway Hill. As the construction of the Gatun dam progressed, the two easterly channels were completely filled during 1908, and the entire flow of the Chagres was sent through the west diversion. The grade of the trestle which spanned this diversion and carried the dump tracks was about 30 ft. above sea level.

In April, 1910, the spillway channel being ready, orders were issued to block the west diversion and turn the Chagres through the spillway. The filling began on April 22, and was entirely completed and the water running through the spillway on April 25. On April 23, 760 carloads of spoil were dumped in the west diversion. These cars would average about 15 cu. yds. per car. The problem was to have plenty of material on hand and to keep it coming until the river was blocked. This was successfully done.

* Of Rourke & Sherman, Consulting Engineers, Boston.

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PAPERS AND DISCUSSIONS

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THE LATEST METHOD OF SEWAGE TREATMENT.

BY EDWARD BARTOW, PH.D.*

(Read before the Sanitary Section, January 10, 1916.)

SEWAGE treatment by aëration in the presence of sludge is the latest development in sewage disposal, although air has always played an important rôle in sewage disposal. Its earliest application was in the exposure of sewage on the ground or in shallow pools, and the disposal of sewage by irrigation is, therefore, an aëration process. No more sewage can be disposed of on land than can be thoroughly oxidized, and the disposal of sewage by dilution in streams depends also on the amount of air present, the amount which can be purified by a stream being limited by the amount of dissolved oxygen present.

Intermittent sand filtration, with sewage added intermittently to sand beds, is an aëration process for, between the periods of flooding with sewage, air is allowed to enter the pores of the sand. The action of contact beds is of a similar nature; coarser material is used, and between the periods of flooding air enters the interstices and is the purifying agent. Sprinkling filters, the most practical process up to the time of the suggestion of activated sludge, depend upon aëration obtained by spreading the sewage in a finely divided state into the air.

NOTE. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the JOURNAL.

* Director, State Water Survey, University of Illinois.

Preliminary to these aëration processes preparatory treatment, consisting in using screens, grit chambers, settling tanks, digestion tanks or chemical precipitation, is necessary. The kind of preparatory treatment varies according to conditions. For example, three European cities use different degrees of preparatory treatment prior to disposal by dilution. Munich uses no screening whatever, the water in the Yser being of sufficient quantity and sufficiently aërated to dispose of the sewage. Hamburg can dispose of its sewage in the lower Elbe, using only coarse screening; but Dresden, on the upper Elbe, must pass its sewage through fine screens before emptying it into the river.

Grit chambers and settling tanks remove suspended matter, and the amount of purification is comparable with the amount of purification by screening. Digestion tanks accomplish the partial destruction of the suspended solids and of the soluble organic matter by the action of anaërobic bacteria. The addition of certain chemicals assists sedimentation and retards digestion, giving an increased amount of sludge, but a much improved effluent. Neither screening, sedimentation, digestion nor chemical precipitation produces complete purification, and aëration processes must complete it.

The latest process, the aëration of sewage in the presence of sludge, has had a gradual development, numerous experiments of blowing air into sewage having been made both in America and in Europe. Until recently none of them were at all promising and the conclusion was that such means of purification were not practical. In this country, the first promising method was that used by Black and Phelps* in New York, in which air was blown through the sewage as it passed over a series of inclined wooden gratings. This sewage was in contact with the air for varying periods up to twenty-four hours and the results were promising enough to cause Black and Phelps to recommend the construction of a larger plant for Greater New York. That plant has not been constructed and the experimental tank has been adapted to experiments with activated sludge.

The next experiments are those reported by Clark, Gage

* Report Concerning Location of Sewer Outlets and the Discharge of Sewage into New York Harbor, (1911) 64-78.

and Adams* at the Massachusetts State Board of Health Experiment Station in Lawrence. Air blown through sewage was found to reduce the organic constituents, and the seeding of the sewage with green growths accelerated the action. Their best results were obtained when the tank contained slabs of slate covered with a brown growth of sewage matters. This treatment produced an effluent which could be filtered at several times the normal rate but it simply prepared the sewage for treatment on sand beds, and was not considered a final process.

Gilbert J. Fowler, of the University of Manchester, England, was in this country in November, 1912, in connection with the disposal of the sewage of Greater New York, and visited the Massachusetts Experiment Station. Fowler and Mumford carried on experiments with a specific bacillus which they named M-7 and which was collected from the waste water from a colliery. This bacillus, with aëration, has the power of separating iron as ferric hydroxide from iron-bearing sewages, carrying down with it the suspended matter and furnishing a non-putrescible effluent. Fowler suggested to Ardern and Lockett, who were in charge of the Manchester Sewage Disposal Works, that they try experiments in aërating sewage on lines somewhat similar to what he saw in Massachusetts. As a result, the activated sludge process is being developed.

The first description of it was given by Ardern and Lockett,† April 3, 1914, at a meeting of the Manchester Section of the Society of Chemical Industry. In their first experiments, Ardern and Lockett used bottles having a capacity of five pints, and drew the air through the sewage by means of an ordinary filter pump. Air was drawn through the sewage until it was completely nitrified, requiring about five weeks. The supernatant liquid was then drawn off, additional sewage added and the treatment repeated a number of times with the retention each time of the deposited solids. As the amount of deposited matter increased, the time required for each succeeding oxidation gradually diminished. Finally, a well-oxidized effluent,

* Annual Report, Mass. State Board of Health, (1913) 45, 288-304.

† Jour. Soc. Chem. Ind., 33, 523-539.

equal to that from efficient bacterial filters, was obtained in from six to nine hours.

In their second series of experiments, reported to the Manchester Section of the Society of Chemical Industry,* November 6, 1914, they used barrels of 50 gal. capacity and added the air through porous tile. They have tried treatment with a continuous flow of sewage without conclusive results. In later experiments they used tanks of 20 000 gal. capacity. Their results were very satisfactory and led to additional work in England, especially at Salford, where Duckworth† and Melling‡ adapted scrubbing filters to the use of the activated sludge process with great success. In August, 1914, I had the privilege of meeting Professor Fowler, and of seeing the work which had been done under his direction. On returning to this country, consulting with Fowler, experiments§ were begun with F. W. Mohlman, at the University of Illinois, on November 2, 1914, using bottles of 3 gal. capacity. On January 4, 1915, a tank 9 in. square and 4.5 ft. deep, in the bottom of which was placed a porous plate made of "Filtros," was put in operation. These plates are made of a very pure and carefully graded quartz, fused together with powdered glass.

The results of our first experiments were similar to those of Ardern and Lockett. Sewage placed in the bottles or in the little tank was submitted to a current of air for a sufficient period to oxidize it completely. The oxidation is best measured by the content of ammonia, nitrate and nitrite nitrogen. Oxidation has been carried to completion five different times with practically the same results. The time required for oxidation differed, but the courses of the reaction were similar. As an example, in one of these experiments, at the beginning, 35 parts per million of ammonia nitrogen were present. (Fig. 1.) The ammonia nitrogen remained practically constant for about four days, then quite rapidly decreased so that at the end of about

* Jour. Soc. Chem. Ind., 33, 1122-1124 (1914).

† Surveyor, 46, 681, 682 (1914).

‡ Jour. Soc. Chem. Ind., 33, 1124-1130.

§ Jour. Ind. Eng. Chem., 7, 318 (1915). *Eng. News*, 73, 647, 648 (1915). *Eng. Record*, 71, 421, 422 (1915). *Eng. Contrg.*, 43, 310, 311 (1915).

seven days it was gone. There were no nitrates nor nitrites present in the raw sewage. The nitrites increased as the ammonia decreased. Then for a few days the nitrites remained constant and then decreased, the nitrates which were zero at the start increasing as the nitrites decreased. At the end of fifteen days, nitrification was complete, the nitrite nitrogen had practically disappeared and the nitrate nitrogen had increased to about 25 parts per million. When the oxidation was complete the

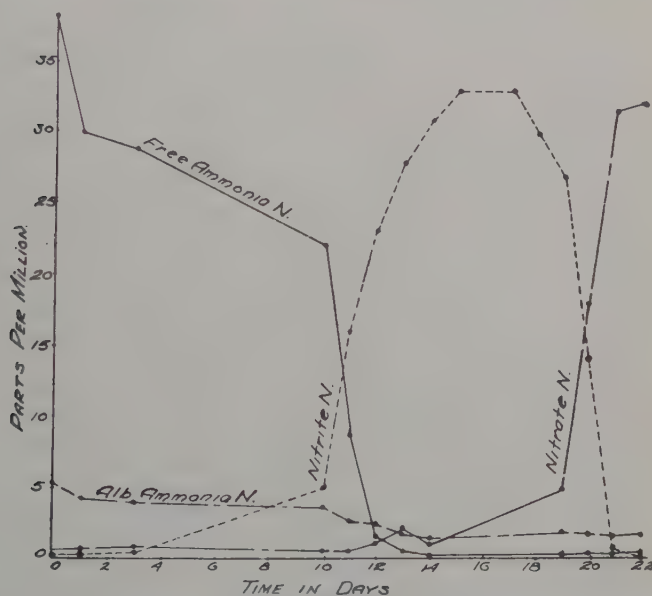


FIG. 1. NITRIFICATION OF SEWAGE. NO ACTIVATED SLUDGE PRESENT.

supernatant liquid was replaced by fresh sewage, the sludge being left. This process was repeated and with each change less time was required for oxidation, as, for example, fifteen days for the first, four days for the second, and two days for the third; and so on, until with the thirty-first treatment oxidation was complete in five hours.

With accumulation of sludge as the process is repeated, the

reaction follows a different course; for example (Fig. 2), using a sewage with 27 parts per million of ammonia nitrogen, the ammonia decreased and is practically eliminated in five hours. The nitrite nitrogen never increased to any extent, the nitrate nitrogen begins to increase almost at the start, increasing as the ammonia nitrogen decreases, and reaches its maximum when the ammonia nitrogen has disappeared. It is not necessary to obtain complete nitrification to obtain a clear or stable effluent. More

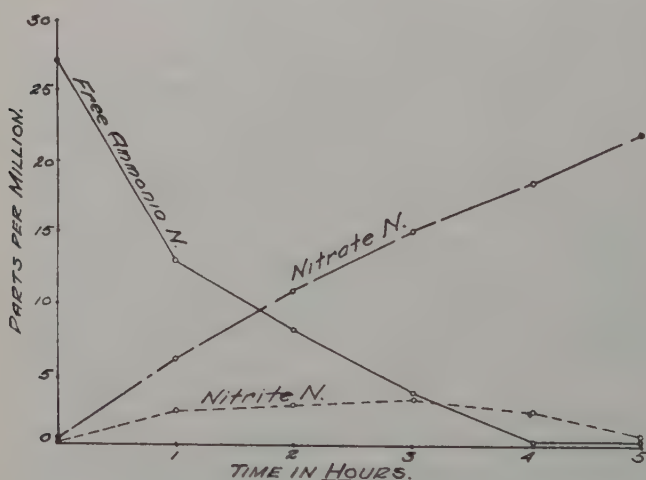


FIG. 2. NITRIFICATION OF SEWAGE. ACTIVATED SLUDGE PRESENT.

information must be obtained before the amount of nitrification required can be known.

The process is undoubtedly bacteriological. The sludge is very rich in bacteria but the number in the effluent is comparatively small. In our laboratory, Mr. Robbins Russell investigated the bacteriological properties of the sludge. Several species of bacteria were isolated from the sludge, including two kinds of nitrifiers and about fifteen other varieties. Experimenting with sterilized sewage, it was found that the nitrifiers alone would not purify the sewage, but that mixtures of the nitrifiers with the other bacteria would completely purify it.

In an article which was presented before the American Chemical Society* mention was made of some worms which developed in the process and which were identified by Prof. Frank Smith of the Zoölogical Department of the Univ. of Illinois as *Aeolosoma Hemprichi*. It seemed possible that these worms might play an important rôle in the purification process. Having isolated about two hundred of these worms as completely as possible from the bacteria and sewage, Mr. Russell added them to sterilized ammonia broth and aërated it, obtaining practically no nitrification. The worms are, therefore, not essential, and the bacteria which were isolated from the sludge did nitrify sterilized sewage.

The fresh sludge is odorless, will putrefy if left with a large amount of water, but after filter pressing it is stable. The dried sludge has an odor similar to that of fertilizers.

As in other sewage disposal processes, the ultimate disposal of the sludge is of great importance. Near the seaboard it is possible to carry it out to sea, but, in the interior, the problem of sludge disposal is often very serious.

In the experimental plant at the University of Illinois in Urbana, we have tried to study all phases of the process,† and have paid especial attention to the sludge.

The amounts of sludge formed and its chemical composition evidently vary with the concentration of the sewage and with temperature conditions. The sewage treated in the experimental plant during rainy weather contains large amounts of diluting water, which reduces the amount of sludge per unit of water and this water carries considerable dirt from the streets, which reduces the nitrogen content of the sludge obtained. Also, during warm weather, bacteriological action is more rapid, and apparently the amount of sludge is considerably reduced.

The sludge obtained in the process is flocculent, resembling a freshly formed precipitate of ferrous-ferric hydroxide. It separates easily from the clarified water, and after settling one hour contains about 98 per cent. of water. On further standing, about one half of this water can be removed. The remaining

* Jour. Ind. Eng. Chem., 7, 318 (1915).

† Jour. Ind. Eng. Chem., 7, 318-320.

material can be dried by filter pressing or by drying on beds of sand and evaporating over steam baths.

The disposal of the sludge can be most easily accomplished if it has manurial value. That activated sludge has manurial value is shown by its chemical composition, by its reaction with various soils and by its effect on the growth of plants. Specimens of sludge obtained at the experimental plant have varied in nitrogen content from 3.5 to 6.4 per cent., the lower values being obtained during periods of high water. Street wash was getting into the sanitary sewers, and, since no grit chamber was provided, the nitrogenous value of the sludge was greatly lowered. The tests of the fertilizer value have been made on the richer specimens which were first obtained.

Through the courtesy of Mr. Paul Rudnick, chief chemist, Armour & Company, Chicago, the availability, according to alkaline permanganate method as used by the New England states, was shown to be 44.7 per cent., and the sludge would be classed as an inferior ammoniate, but the availability according to the neutral permanganate method which has been adopted by the southeastern states was shown to be 89.0 per cent. and would, therefore, be classed as satisfactory.

Tests have been made by Prof. C. B. Lipman, according to a method described by Lipman and Burgess,* in which a fertilizer and a soil are incubated for a month. The amount of nitrogen changed into nitrate is then determined. This amount is an index of the availability of the nitrogen with respect to the soil used. The results obtained were reported by Professor Lipman as follows:

"The activated sludge used contained 6.2 per cent. total nitrogen and no nitrate. The hundred grams of soil in every case contained nitrate as follows:

Anaheim soil.....	1.0 milligram nitrogen.
Davis soil.....	.3 milligram nitrogen.
Oakley soil.....	.1 milligram nitrogen.

"The amounts of nitrate produced in one month's incubation from the soil's own nitrogen and from the nitrogen of the sludge mixed with the soil in the ratio of one part of sludge per hundred of soil is as follows: .

* Univ. of Calif., Bull. 251 (1915).

Anaheim, without sludge, 6 milligrams nitrate produced.
 Anaheim, with sludge, 10 milligrams nitrate produced.
 Davis soil, without sludge, 4.2 milligrams nitrate produced.
 Davis soil, with sludge, 14 milligrams nitrate produced.
 Oakley soil, without sludge, 2.2 milligrams nitrate produced.
 Oakley soil, with sludge, 4 milligrams nitrate produced.

"The Davis soil is the best nitrifying soil of the three, especially for high-grade organic material; Anaheim is next and the Oakley by far the poorest. Indeed, the last named does not nitrify, in a period of a month in the incubator, the nitrogen of dried blood.

"These figures indicate that the general tendency is to make available the nitrogen of sludge in type soils at about the same rate that nitrogen is transformed into nitrate in such organic, nitrogenous fertilizers as fish guano. While it seems to hold a medium position, it nevertheless resembles very much more closely in its general characteristics, so far as available nitrogen is concerned, the so-called high-grade organic nitrogenous fertilizers, dried blood and high-grade tankage, etc., rather than the low-grade nitrogenous fertilizers, steamed bone meal, cotton seed meal, garbage tankage, etc."

Although the chemical tests and the nitrification tests with soils indicate that the activated sludge has a high fertilizer value, the final test must be its effect on plant growth. Pot cultures, using wheat, were started in March, 1915,* under the general direction of Prof. C. G. Hopkins and with the assistance of Mr. J. C. Anderson. The contents of the pots in which the wheat was planted were as follows:

Pot Number.	1. Grams.	2. Grams.	3. Grams.	4. Grams.
(1) White sand.....	19 820	19 820	19 820	19 820
(2) Dolomite.....	60	60	60	60
(3) Bone meal.....	6	6	6	6
(4) Potassium sulphate.....	3	3	3	3
(5) Activated sludge.....	0	0	20	0
(6) Extracted sludge.....	0	0	0	20
(7) Dried blood.....	0	8.61	0	0

Each pot contained an equivalent of 5 tons per acre of dolomite, one-half ton per acre of bone meal, and 500 lbs. per acre of potassium sulphate.

Pot 1, the check pot, contained only 60 mg. of nitrogen,

* Jour. Ind. Eng. Chem., 7, 318-320.

which were added in the bone meal. This small amount was without significance since the same amount was added to the other pots. Pot 2 contained an equivalent of 120 lbs. of nitrogen per acre, added in the form of dried blood. Pots 3 and 4 contained an equivalent of 120 lbs. of nitrogen in the form of dried activated sludge (one ton of sludge) per acre. Following is an analysis of the sludge used:

	Per Cent.
Total nitrogen.....	6.3
Phosphorus (P_2O_5).....	2.69
Ether soluble (three hours' extraction).....	4.00
Ether soluble (sixteen hours' extraction).....	11.8

Thirty wheat seeds were planted, two seeds in each of fifteen holes, in each pot. In four days the plants were up in each pot, and in ten days were 5 ins. high. At the end of eighteen days, the plants were thinned to fifteen of the best in each pot, in most cases leaving one plant to each hole. In twenty days from date of planting, there was a marked showing in favor of the plants in pots 3 and 4. In twenty-three days, the plants in pots 3 and 4 were growing far ahead of those in 1 and 2.

The plants in pot 2 fertilized with the same amount of nitrogen grew much slower than those in pots 3 and 4. The reason for the poor showing of the plants in pot 2 is not known.

In thirty days, a slight brown mold, which may have been due to the dark, damp weather, appeared on the larger plants, and powdered sulphur was used to fight it. During the fifth and sixth weeks, the plants in the pots fertilized with the sludge, which had grown fully three times as large in height and in amount of foliage as those in the pot fertilized with dried blood, began to yellow. About half of the foliage died, leaving two healthy stalks to each plant. The plants possibly grew so fast, at first, that all the foliage which had started could not develop. The remaining stalks immediately grew stronger and of a deeper blue-green color. After nine weeks, the plants were strong and healthy.

In fourteen weeks the plants in pots 3 and 4 began to head, and in fifteen weeks there were about twenty good heads in each.

The plants in pot 1 were very weak, while those in pot 2 were just beginning to develop heads.

When it was first noticed that the plants fertilized with sludge were growing much better than those fertilized with dried blood, in order to confirm the results a second series of pot cultures was started. In this series the sludge was compared with dried blood, nitrate of soda, ammonium sulphate and gluten meal. This series contained fourteen pots, two check pots, six containing nitrogen equivalent to an application of twenty grams of sludge, and six containing nitrogen equivalent to thirty grams of sludge. The plants in this series grew faster than those in the first because of better weather. They showed exactly the same characteristics that the plants in the other series showed, the plants fertilized with sludge being the best and the results confirming the results obtained in the first series. At the end of five weeks striking differences were noticeable. The pots containing the equivalent of 30 g. of sludge gave no better results than those with an equivalent of 20 g.

When the wheat matured it was carefully harvested and calculations made to determine the yield per acre. The results are shown in a table.

AMOUNTS OF WHEAT AND STRAW OBTAINED IN THE FIRST SERIES.

Pot Number.	1.	2.	3.	4.
Number of heads.....	14	15	22	23
Number of seeds.....	85	189	491	518
Weight of seeds.....	2.38 g.	5.29 g.	13.748 g.	14.504 g.
Bushels per acre (calculated)...	6.2	13.6	35.9	37.7
Average length of stalk.....	19.4 in.	23 in.	35.4 in.	36.1 in.
Weight of straw.....	2.25 g.	8.25 g.	26.75 g.	26.21 g.
Tons per acre (calculated).....	0.18	0.68	2.23	2.18

The control series gave results corresponding to those of the first series.

The surprisingly rapid growth of the wheat fertilized by the sludge must be due for the most part to nitrogen present in a very available form. It may be due in part to the phosphorus (2.69 per cent.) which is present in the sludge, which, at the time of making the pot cultures, we did not consider, since it was

present in such a small quantity. The growth may be due in part to the organic matter present in the sludge, since the sand used contains no organic matter. The cause of the molding of the leaves has not yet been determined. It was quite noticeable that the mold appeared chiefly on the leaves of rapid growing plants. In the first series it attacked only plants fertilized with sludge, while in the second series it also attacked the plants fertilized with gluten meal. The rapid growing leaves are naturally more tender than those which grow slowly and consequently are more easily attacked by mold spores. The mold evidently does not come from the sludge, because the extracted sludge surely would be sterile, and plants fertilized with it showed the same mold. Plants fertilized with gluten meal also had the mold.

The sludge causes such a rapid growth of wheat that it should be valuable to truck gardeners, to rush the spring crops. To test its value to the market gardener, three plots, each 2 ft. by 3 ft., were laid out. One was not fertilized, one was fertilized with an equivalent to 126 pounds of nitrogen, one ton of sludge per acre, and the third with an equivalent of extracted sludge. On April 24, 1915, two rows of radishes and lettuce were planted in each of the three plots. The plants in the plot where the extracted sludge was used came up first, a little ahead of those in the plot where the unextracted sludge was used. At the end of two weeks the lettuce and radishes of the treated plots appeared to be twice the size of those in the untreated plot. At the end of four weeks the plants were thinned. The roots of the radishes from the treated plots were already red and quite rounded near the tops, while those from the untreated plots had not yet started to swell and had not become red. The lettuce plants from the treated plots were nearly twice as large as those from the untreated plots.

On June 1, thirty-eight days after planting, the six best plants of lettuce and radishes were taken from each plot. The differences in size were very marked.

COMPARISON OF THE LETTUCE AND RADISHES FROM UNFERTILIZED AND FERTILIZED PLOTS.

Plot.	Treatment.	Wt. of Lettuce.	Wt. of Radishes.
1	None.....	4.5 g.	23.4 g.
2	Sludge.....	6.3 g.	63.0 g.
3	Extracted sludge.....	6.8 g.	68.0 g.

The increase in weight, due to the sludge, is 40 per cent. in the lettuce, and 150 per cent. in the radishes. The radishes from the sludge pots when cut open and eaten were found to be very crisp and solid and to have a good flavor.

These pot cultures and gardening experiments show that the nitrogen in "activated sludge" is in a very available form and that activated sludge is valuable as a fertilizer.

The process is attracting a great deal of attention in America, and a very good statement concerning the work being done is given in *Engineering News* of July 15, 1915,* in which Mr. M. N. Baker has given an editorial review of the subject. The most extensive work is being done at Milwaukee. An article by Mr. T. Chalkley Hatton† gives a more complete account of the Milwaukee experiments. Two tanks of 1 x 5 x 10 ft. deep and one tank 10½ x 32 x 10 ft. deep have been operated on the fill-and-draw plan and one tank 10½ x 32 x 10 ft. deep is operated on the continuous plan. The Milwaukee Sewerage Commission has awarded contracts for the construction of a plant to treat 2 000-000 gal. of sewage per day by continuous flow. At Baltimore, they have been working on a small scale but have adapted two of the new Imhoff tanks for the use of this process and it is expected that in a short time they will be using activated sludge on a large scale. At Washington, the Hygienic Laboratory of the Public Health Service is experimenting on a small scale and is coöperating with the Department at Baltimore in their experiments. At Cleveland, experiments are being carried on in the sewage experiment station. They have adapted tanks 5 x 10 and 5 ft. deep which they used in their sewage experiments to the process, and while it has barely begun they are getting prom-

* *Eng. News*, 74, 164-171.

† *Eng. News*, 74, 134-137.

ising results. Experiments are to be carried out on a larger scale. At Regina, Saskatchewan, experiments on a considerable scale have been carried out, and their results are reported by R. O. Wynne-Roberts.* At Houston, Tex., they are planning to use the process in a plant to treat ultimately the sewage from 160 000 people. They do not expect to obtain complete nitrification, as a completely purified effluent is unnecessary. In Chicago, the Sanitary District of Chicago is using tanks about 2 ft. in diameter and 8 or 10 ft. high with quite satisfactory results, using the waste from the stock yards, one of the most difficult of wastes to treat.

At the University of Illinois four reinforced concrete tanks have been completed and put in operation. These tanks, operating on the fill-and-draw system, are designed for studying in a comparative manner the amount of air required, the best method for distributing the air, the time required for purification and the quantity and quality of activated sludge formed. The tanks are located in the basement of the power plant in a room which is not affected by heat from the boilers and where conditions are similar to those which would be obtained by housing a plant. The sewage is pumped to the tanks from city of Champaign main sewer by a 2 h.p. centrifugal pump run by a direct connected motor.

Each tank is 3.17 ft. square, giving an area of 10 sq. ft., and is 8.42 ft. in depth above 1½-in. Filtros plates which are used for diffusing the air. In two tanks there are 9 plates, each 12 in. square, covering the entire floor. In the third tank there are 3 plates covering half the area of the floor, forming the bottom of a central trough. The remainder of the bottom slopes to the plates at an angle of 45 degrees. In the fourth tank is a single plate in the center covering one-ninth the area, with the bottom sloping to it at an angle of 45 degrees from all sides. Below the plates is an air space 4 in. deep. A petcock is provided to relieve the air pressure when draining the tank and to prevent air bubbles from rising and stirring up the sludge. The air obtained from the University compressed air plant at a pressure of 80 lbs. is reduced by a reducing valve to 8 lbs., and is further regulated

* *Canadian Engineer*, 29, 112, 113.

by a hand-operated valve before passing through meters on each tank. The pressure under which it enters the tank is sufficient only to overcome the pressure of the sewage and the friction of the plates, equivalent to about 8 ins. of mercury, or a little less than 4 lbs. per sq. in.

Two outlets for the effluent are respectively 2.5 ft. and 5.58 ft. above the porous plates. A tank can be filled in six minutes and drained to the lower outlet in eight minutes.

Experience has shown that a lower outlet connected to a floating outlet would be preferable. A fixed outlet is objectionable because sludge is at times drawn out with the effluent. In fact, no accurate data has been obtained concerning the quantity of sludge formed, because we have been unable to determine how much has been lost with the effluent. In order to prevent this loss, a floating outlet made of 2-in. pipe connected together with loose joints, has been placed in tank C. The effluent flows to the outlet through a screen of copper wire of about 16 mesh, which is fastened on both sides of an iron frame 1 ft. square. With this arrangement no sludge has been lost and we expect to obtain accurate data concerning the amount of sludge formed from the sewage.

The amount of sludge must be determined by weight on the dry basis, for it has been noted that its volume and rate of settling varies with the amount of air applied. If an unusually large amount of air has been applied, the sludge will settle more slowly and will occupy a much greater volume even after prolonged settlement than it does when less air has been applied.

Building Up of Sludge. — If, in accordance with previous practice, activated sludge is built up by complete nitrification of each portion of sewage added, it would require several weeks to put a plant in operation.

In order to obtain sludge more quickly, the English investigators have used sludge from sprinkling filters. At Milwaukee, Imhoff tank sludge has been aerated until it is aerobic and similar to activated sludge. Such a source of sludge would not be available in many places, especially at newly installed plants. We have attempted to shorten the period of sludge formation.

Tanks A and B were filled with the same kind of sewage on

May 5, 1915. The sewage in tank A was aerated continuously while the sewage in tank B was aerated twenty-three hours, allowed to settle, the supernatant liquid withdrawn and the tank refilled with fresh sewage in one hour. This cycle was repeated and determinations of the amount of sludge and of the degree of purification were made daily.

At the end of ten days, after one hour's settling in Imhoff cones, 1.0 per cent. of the volume in tank A consisted of sludge, while about 10 per cent. of the volume in tank B was sludge. The effluents from tank A, which had been aerated ten days, and from tank B, which had been aerated one day, were equally stable, while that from tank B was clearer.

Tank B was continued in operation, changing the sewage every twenty-four hours, until, after fifteen days, nitrification was complete. Then the sewage was changed every twelve hours and nitrification was again complete after eight days. Then the sewage was changed every six hours, but many of the effluents with the six-hour cycle were putrescible and it is necessary at intervals to aerate for longer periods. This comparison indicates, however, that sludge may be satisfactorily activated by changing the sewage before nitrification is completed, and that the sewage may be changed at frequent intervals.

Tank A was therefore cleaned and fresh sewage added every twelve hours. The stable effluents were obtained in seven days, and complete nitrification occurred in eighteen days, after which the sewage was changed every six hours. The effluents obtained from the tanks during this six-hour cycle were not all stable, yet the average improvement was so great that the conclusion is reached that activated sludge may be built up by changing sewage at frequent intervals without complete nitrification of each dose of fresh sewage. A considerable degree of purification is also obtained from the beginning of the operation, and the time for building up adequate sludge for the process is cut down very decidedly. A later experiment with tank C showed that satisfactory activated sludge could be built upon a six-hour cycle.

Diffusion Area Required. — The bottom of tank C contains

3 sq. ft. of Filtros plates, as described above, while the bottom of tank D contains 1 sq. ft. These tanks were put in operation July 6 and the sewage was changed every six hours. There was a noticeable difference, tank C giving some stable effluents after five days, while tank D did not give stable effluents in eighteen days. The sludge from C was of good appearance, while that from D was not as flocculent and at times had a septic odor. During the comparative experiment an average of 450 cu. ft. of air per 400 gal. of sewage was used with tank C and 360 cu. ft. of sewage with tank D. The amount of air given tank D was always sufficient to keep the sludge mixed with the sewage. In fact, the sewage in tank D was agitated much more violently than that in tank C. We have concluded that 1 sq. ft. of Filtros plate per 10 sq. ft. of floor area is hardly sufficient. Of the four tanks, tank C, with 3 sq. ft. of Filtros plate per 10 sq. ft. of floor area, has given the best results.

We have noted that it is quite essential that the plates be as nearly as possible at the same level as a variation of $\frac{1}{4}$ in. in level will cause uneven air distribution. The distribution seems to become more uniform the longer the plates are used.

Quality of Effluents.—The quality of the effluents has usually depended more on the strength of the raw sewage than upon any other variable. The tanks, when operating on a six-hour cycle, were filled at 9 A.M., 3 P.M., 9 P.M. and 3 A.M. The strength of the raw sewage, estimated by the ammonia nitrogen values, averages for the 9 A.M. sewage between 20 and 35 parts per million, and for the 3 A.M. sewage between 3 and 12 parts per million. Nearly all of the 3 A.M. sewages have given stable effluents, but the strong morning sewages have quite frequently given putrescible effluents. Unless the sludge is in good condition and well nitrified, a strong sewage cannot always be purified in four and one-half hours even by increasing the air to 800 cu. ft. per 400 gal. In the normal working of the plant the sludge will usually regain its "activity" if 800 cu. ft. of air is applied for several periods after the strong sewage has been added.

At times, however, with a succession of strong sewages, it is necessary to increase the period of aëration in order to obtain

good effluents. Ardern and Lockett* noted in their first paper that, if the aëration was stopped before the sewage was well nitrified, the activity of the sludge would be inhibited. When strong sewages are to be treated, a definite cycle of operation cannot be established without provision for longer aëration of the sewage or separate aëration of the sludge. In order to keep the sludge in its most active state, complete nitrification of each sewage is necessary. Effluents are usually stable if 50 per cent. of the free ammonia is removed and 2 to 3 parts per million of nitrogen as nitrates are present.

The greatest efficiency in air consumption will be obtained when enough air is used to make the sewage non-putrescible and to keep the sludge activated. The operation of the plant during six months has suggested the advisability of studying more carefully such other features of the process as the amount of sludge formed, the building up of nitrogen in the sludge, and the composition of the effluent gases.

* Jour. Soc. Chem. Ind., 33, 623-639.

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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SERVICE FOR THE SOCIETY.

By EDMUND M. BLAKE,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

THE building of a battleship depends upon the correlated service of every one engaged upon its construction, from the designer and template maker down to the man who heats the rivets that go in the hull. This service takes a multitude of forms, but is all guided toward that supreme moment when hawsers are loosed and the mighty hull slides down the ways at the launching. The completion of the structure, the perfection of details and the armament of the powerful fighting machine follow. Then come the tests, the acceptance and the placing in commission. The ultimate success of the battleship depends upon every detail of its design, the quality of every piece of material entering into its construction and the efficiency of the skilled and unskilled labor employed in its fabrication. The keynote is quality, whether in design, material or workmanship.

The building up of an engineering society as well depends upon the correlated service of every member. Application for membership and its acceptance should carry with it not only the willingness to give, but the intention of giving service. We who are following the greatest profession in the world have

NOTE. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the JOURNAL.

* Civil Engineer, Brookline Mass.

adopted engineering as our life work only after careful thought, deep consideration of all the branches of life's activities and usually a long scientific or practical preparation. If we are not loyal to engineering as the profession we have ourselves chosen, we should abandon it at once. If we are loyal to it, then the upbuilding and strengthening of our chosen profession should be one of the primary motives of our work. We cannot draw from a bank unless we have put in something to draw upon, and the more we put in the more we can draw out. It is equally true of the engineering profession. We must invest in it all we have, constantly adding to that investment as the years go by, if we are to share in the full returns.

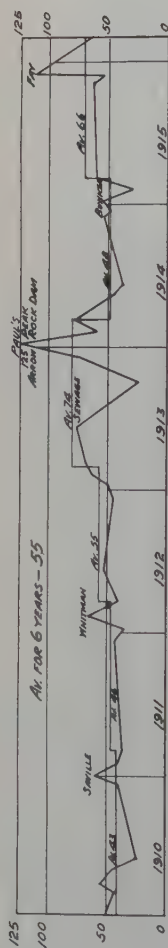
An engineering society represents a coöperative effort by the engineering profession to consolidate its members into a concrete and united organization for the upbuilding and strengthening of the profession, for the benefits of personal contact and professional interchange of engineering knowledge, ideas and advice, for the purpose of commanding a broader recognition and a higher valuation of the engineering profession by the public, and for the publication and dissemination of the best in engineering theory, design and practice and the compilation of data. The individual member should be instilled with a true spirit of service, with an ambition to contribute toward the accomplishment of these purposes more than his share, and with a very clear realization that his application for membership in the society is not accepted primarily as adding one more wheel unit to the installation, but rather in the nature of additional second-feet of flow to be credited to plant capacity.

With this conception firmly established in his mind, the engineer who joins the society will consider of first importance the question of what he can add to the society and not of what he can get out of the society in return for his annual dues. Service for the society will follow, and soon there will be no need of arguing the other side, — that of the benefits to be received from membership in the society. This conception will not foster any false valuation of present personal contribution to the society, but rather will create an ambition to make the net final contribution represent the maximum possible individual output,

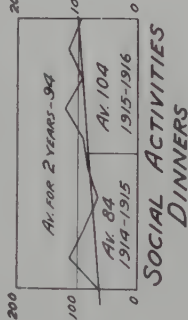
always remembering that the engineering society is the one great concrete medium of contribution to the engineering profession.

The Boston Society of Civil Engineers was founded in 1848, and is the oldest engineering society in the United States. Its membership comprises those interested in mechanical and electrical as well as in civil engineering, and its officers have included prominent members of all three branches of the profession. To-day, its total active membership has reached one thousand, composed of members, junior and associate members and honorary members, and it has established a permanent and safely invested fund of over thirty-seven thousand dollars. It seems, to use an inadequate simile, like a big battleship ready for launching, but that does not mean necessarily a membership limited to one thousand with a waiting list, nor a permanent fund of only thirty-seven thousand dollars, nor in any way a reflection adversely upon the net result of past efforts, but rather the highest commendation for the achievements and distinction already won. The Society is now sixty-eight years old. Many of its present members may not answer the one hundredth anniversary roll-call in 1948. It can never hope to approximate the membership total of the American Society of Civil Engineers, but in quality, solidity and scientific achievement, in service to the engineering profession, fraternal *esprit de corps* and its contribution to the engineering literature of the world, it is possible for the Boston Society of Civil Engineers to establish its claim as the foremost engineering society in the United States on or before its centennial anniversary in 1948. In the intervening years, the structure must be completed, the details perfected and the final armament installed, and always the keynote must be quality in design, material and workmanship. That is wherein lies the opportunity for service and accomplishment. The honor of the Society should be made the honor of its every member.

The expression of the will of the Society should be reflected in its Board of Government, and the membership should express its will openly and often. That points plainly to the first duty of every member,—attendance regularly at Society meetings and other functions unless prevented by urgent necessity. This means on the average only about thirteen evenings out of the



SANITARY SECTION MEETINGS



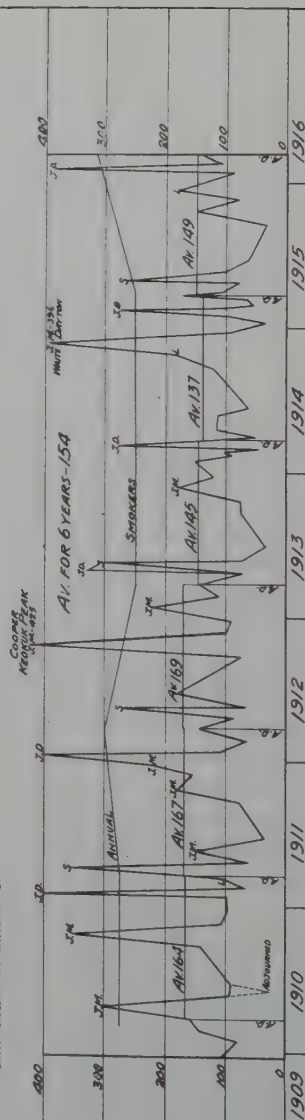
SOCIAL ACTIVITIES DINNERS

ATTENDANCE

A.D. - Annual Dinner
J.M. - Joint Meeting
S.D. - Special Dinner
S. - Special Meeting
L. - Ladies' Night
Attendance are based on all data shown on Diagrams.

DIAGRAMS

Reviewed by *W. H. C. C. C.*
Committee on Social Activities.



BOSTON SOCIETY OF CIVIL ENGINEERS - ATTENDANCE

year, or probably not more than 52 hours out of 8 760 hours in the year, which is only about one half of one per cent. of a man's entire time. Attendance will result in knowledge of the *modus vivendi* of the Society, in transactions of Society business that more nearly represent the best judgment of the greatest number of members, and eventually will bring about those changes which must inevitably accompany advance and progress. There is no reason why any society should be controlled by a relatively small clique or group of members, but if the membership does not attend the business meetings, the society must be controlled by some small group that does attend. So the value and importance of attendance becomes evident and is very great, and it will soon transform outside criticism by members into inside effort to bring about synchronous and harmonious progress.

Certain diagrams are appended to this article with the intention of giving information. They do not, perhaps, have any direct bearing upon the matter under consideration. These diagrams give a graphical analysis of the actual attendance at the various functions of the Boston Society of Civil Engineers since 1909. The points plotted are taken from the published reports of annual meetings, and the attendance thus shown includes members and guests as well as members of the Boston branches of Mechanical and Electrical Engineers at joint meetings. The averages are calculated from the figures represented by all of the plotted points. The number of functions each year is shown by the number of points plotted. The records of attendance for the Sanitary Section and the social activities dinners are also shown in diagrams.

The main Society diagram shows an average attendance of 154 at the meetings plotted, covering the period of six years from March, 1910, to March, 1916. While exact data are not available, it is not likely that the average attendance of members for this period exceeded 100, and probably 80 would be more nearly correct. This is in the nature of a guess, as it is not feasible to determine the exact number of members present at the various functions of the Society without a standing count or roll-call, and this has never been undertaken. The diagram shows

80 meetings in six years, or an average of about 13 each year. The total membership of the Society during this period has been as follows:

Year.	Membership.	Annual Increase.
In March, 1910.....	723.....	
In March, 1911.....	797.....	74
In March, 1912.....	806.....	9
In March, 1913.....	823.....	17
In March, 1914.....	837.....	14
In March, 1915.....	828.....	91
In March, 1916.....	999.....	71

The average total membership has been 845, with an average annual increase of 46 members. If the larger figure of 100 for the average attendance of members is taken, it will be seen that the total number of members attending the meetings of the average year has been 1 300, which represents an average of less than two meetings attended by each unit of the average total membership of the Society.

There would appear to be no valid reason why nearly every member of the Boston Society of Civil Engineers should not find it possible to attend at least one half of the ten regular monthly meetings of the Society year. It even seems to be a matter of duty and loyalty. Such an attendance would have a far-reaching effect upon the progress and development of the Society. Allowing for non-resident membership absences and absences for other valid reasons, this would mean a total attendance of members at the meetings for the coming year of over 4 000, against an average of about 1 300 for the past six years. Even an indifferent consideration of this possibility should lead every member to do his duty during the Society year of 1916-1917.

The diagram of social activities dinners, with its average attendance of 94 for the past two years, largely of members, is simply a graphic demonstration that social functions of that nature supplied an unvoiced demand of the Society and met with instant response. The results have been most gratifying,

and the effect upon the *esprit de corps* of the Society most beneficial.

The diagram of Sanitary Section meetings shows an average attendance of 55 for the six-year period, largely of members, which is probably more than 50 per cent. of the average attendance of members at the meetings of the main Society for the same period. It is a strong right arm of the Society, and its development as a specialized branch should be fostered by the main Society, while the members of the Sanitary Section should not overlook their obligations to the main Society.

It is hoped that these diagrams may prove of interest. Their lesson and the message of this article is that the best and highest interests of the Boston Society of Civil Engineers in the immediate future will be fostered and strengthened by a steadily increasing attendance of members at all of its functions, but especially at its regular meetings where business is transacted and professional papers are presented with an opportunity for public discussion. A large responsibility in bringing about this result will rest naturally with the Committee on Papers and Program, but a loyal response must be made by the members, and it is primarily by attendance at regular meetings that each member can best render his service for the Society. Thus the internal growth of the Society will undergo a wonderful development, its recognition and valuation by the public will be increased tenfold, and the standing of the engineering profession in the community will reach a high level never before attained. Meanwhile applications for membership will become more spontaneous with a rising standard of qualification. Finally, if the Permanent Fund is increased and invested on the present basis only, a sum probably exceeding \$115 000 should be available by 1945, which would make it possible to celebrate the 1948 Centennial Anniversary in a new building owned and occupied by the Boston Society of Civil Engineers which would be a monument to those who had labored for its attainment and a pride to all future generations of its members. The fulfillment of this prophecy is not impossible. It will depend upon individual service for the Society.

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

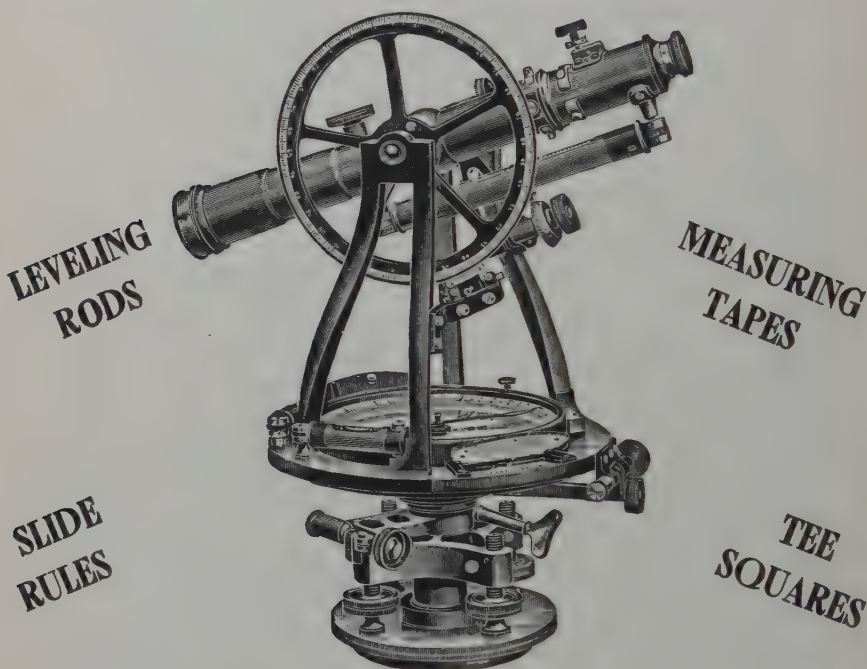
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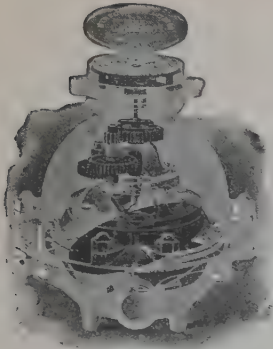
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